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UTAH SCIENCE

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Most tomato breeding work in Utah has been directed toward developing varieties that are resistant to **Verticillium** wilt, **Fusarium** wilt, and curly-top, a virus disease spread by leaf hoppers. These diseases have had a definite adverse economic effect on the tomato canning industry in Utah.

Now that resistant varieties are available, a new problem has arisen. The elimination of the foreign farm labor supply, chiefly Mexican Nationals, in 1964 hit the West Coast vegetable industry hard. Labor costs for handling these crops skyrocketed. As a result, mechanization developed rapidly. Tomato varieties were especially developed to ripen most of their fruit at the same time. These varieties had tougher skins and firmer flesh to withstand the stresses of once-over mechanical harvesting.

California's warm climate and long growing season allow tomatoes to be directly seeded in the field which saves the expense of transplanting operations. This is not possible in Utah, however, because of our cold spring weather and short growing season. To offset this disadvantage and pave the way for mechanized harvesting in Utah, Utah State University scientists are striving to develop tomato strains that will germinate in cool soils and still retain disease resistance and the qualities necessary for modern processing. Read more about the different facets of tomato production in this issue of **Utah Science**.

UTAH SCIENCE

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A history of tomato breeding in Utah

Most of the tomato breeding work at USU has had the goal of producing varieties that are resistant to the diseases that cause heavy losses in tomato crops grown in the state. The Biennial Report of the Director of the Utah Agricultural Experiment Station in 1936 reported that *Verticillium* wilt was more responsible for tomato crop failures than *Fusarium* wilt. It reported also that "curly-top" disease (a plant virus spread by leaf hoppers) developed in epidemic proportions in 1930, 1931, 1934, and 1935, resulting in an annual loss of over 1 million dollars to the state."

The late Dr. H. L. Blood, who then was working with the Utah Agricultural Experiment Station and the United States Department of Agriculture, assembled tomato varieties from all over the world for many years. These he planted in places which favored the development of the diseases in an attempt to find varieties which were able to stay healthy under such conditions. Each year in Hurricane, Utah, he planted more than 50,000 plants. He found no varieties with enough resistance to curly top to justify using them in a breeding program.

When Loran Blood's work showed that none of the varieties then being grown had characters that would be useful in a program designed to produce curly-top resistant tomatoes, the United States Department of Agriculture sent him and an interpreter, Lewis Tremelling, to South America for the purpose of collecting tomato plants where the tomato originated. They spent the winter of 1937-1938 in the High Andes and in the lowlands along the coast. They looked for and collected samples wherever they went. Many of the tomatoes they collected were so different from the tomatoes of commerce that most of us would not recognize them as tomatoes. Their collections formed the basis for a complete revision of the

genus *Lycopersicon*, and tomatoes from the Blood-Tremelling expedition have been used in many subsequent tomato breeding projects in many parts of the world.

After his trip to South America, Dr. Blood carried on two tomato breeding projects: (1) He used wild, green-fruited collections from South America, which have high curly top resistance, as parents in crosses with regular tomato varieties, in an attempt to incorporate curly-top resistance into commercial type tomatoes. (2) He found resistance to *Verticillium* wilt in a small, red-fruited variety, called Peru Wild, and he incorporated its wilt resistance into large fruited varieties.

The major obstacle to the development of a satisfactory curly top-resistant tomato is the barrier of sterility. Fruit is formed by plants of *Lycopersicon esculentum*, the tomato of commerce, when they are pollinated by pollen from a variety of the green-fruited curly top-resistant species, *L. peruvianum* var. *dentatum* or *L. peruvianum* var. *humifusum*. Seeds start to form in such fruits, but most of them abort before the fruit is mature. The few plants that have resulted from such crosses have had resistance comparable to the resistance of the wild parents. These F₁ plants do not set fruit with pollen from *L. esculentum*, but their pollen, when it is transferred to the stigma of *L. esculentum*, produces fruit and some seeds. The plants coming from these seeds and their offspring occasionally carry some curly top resistance, but it does not compare with the resistance of the original wild parent. Dr. Blood developed plants with more resistance than was

found in any commercial varieties. His successors, Orson Cannon, Wade Dewey, and Mark Martin worked toward that goal without much improvement. Dr. Martin, now at Washington State University, released CVF4 in 1966 and C5 in 1970 as curly-top resistant breeding stocks for use by plant breeders. Both of these releases have a degree of resistance that is considerably better than that of commonly grown tomato varieties, but the resistance is inferior to that found in the wild species.

The development of tomatoes with resistance to *Verticillium* wilt did not encounter the difficulties which were encountered in the curly-top program. At the time of his death in 1948, Dr. Blood had developed wilt resistant tomatoes with good fruit size, but all of them were light yielders and matured too late in the season. A greenhouse method of testing for *Verticillium* wilt resistance was developed by Orson Cannon in 1949. This made it possible to eliminate wilt susceptible seedlings. Subsequent work by Schabille, Cannon, and Waddoups showed that resistance to *Verticillium* wilt was controlled by a single dominant gene. This knowledge made it possible to develop wilt resistant varieties which had desirable horticultural characters by using a simple backcross program.

Two new *Verticillium* wilt-resistant varieties, Loran Blood and VR Moscow were released in December, 1952. Field trials in 1951 and 1952 had demonstrated that these new varieties were clearly superior to any of the varieties then being grown in Utah. Within a very short time, most of the commercial tomato acreage of the state was planted to these two varieties.

Inasmuch as it was possible to incorporate resistance to both *Verticillium* and *Fusarium* wilts into the same

(Continued on page 5)

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Utah's tomato industry— its development and future

J. LAMAR ANDERSON and ALVIN R. HAMSON

Utah's canning industry is an important segment of our agricultural economy. In 1970, growers received about 3 million dollars for their processing crops. The canning industry also paid an additional 3 million dollars to their employees. Taxes and supplies from supporting industries amount to approximately 10 million dollars a year. Therefore, the total value of the vegetable canning industry to Utah is nearly 16 million dollars annually. Tomatoes account for the largest single value of a crop for processing in Utah.

EARLY BEGINNINGS

Jack Pierce opened the first cannery in Utah on West 29th Street in Ogden in 1868. During that first year, tomatoes were peeled by hand and some 1,000 cases were processed. The Utah canning industry gradually grew until there were 36 commercial processors canning tomatoes in the mid-1940s. At this time, about 8,500 acres of tomatoes were grown for processing, with an average yield of 10 tons per acre. This period marked the high point of tomato production in Utah. During the last 5 years, tomato acreages in Utah have ranged from 2,000 to 2,500 acres, with an average yield of 15 tons per acre. These tomatoes were processed at 8 plants from Utah County north to Box Elder County.

Research at Utah State University has been an important factor in the development and survival of the canning industry in Utah. Tomato varieties were bred for resistance to Fusarium and Verticillium wilt, two serious fungus diseases of tomatoes. Nearly all of today's tomato varieties

trace their resistance to these diseases to the original resistant stocks developed at the Utah State Agricultural Experiment Station. Cultural studies at the Experiment Station provided the basis for the economical production of seedling tomatoes in Southern Nevada's Moapa Valley for transplanting in the tomato fields of northern Utah. Fertilizer and weed control recommendations from the University have been important in raising tomato yields in Utah. Twenty-five years ago, research was initiated to develop resistance to the curly-top virus, which can be devastating to tomatoes when large populations of viruliferous leaf hopper vectors are present. Wild tomato species were brought from South America to use as a source of curly-top resistance in a breeding program. Progress that has been made in developing tomato resistance to curly-top has been centered at Utah State University.

TOMATO MECHANIZATION

The termination of Public Law 78 on December 31, 1964, eliminated the foreign labor supply upon which agriculture, and in particular the vegetable industry, had relied very heavily. As a result of losing much of the agricultural labor which had been used extensively by tomato growers, the mechanization of tomato production developed rapidly. In 1964, California produced 120,000 acres of tomatoes of which were picked by hand. In 1965, one-fourth of the tomatoes grown in California were harvested by mechanical pickers. By 1968, California produced 231,000 acres of tomatoes and now the processing tomatoes are all mechanically harvested. The development of mechanization to

eliminate practically all of the labor needs allowed the tomato acreage to double in 4 years. California now produces about 80 percent of the tomato products in the United States.

Mechanization in Utah has developed much more slowly than it did in California. Utah has had a labor force large enough to harvest the tomato crop manually; consequently, mechanical pickers have not harvested a very high proportion of Utah's tomato crop. Four mechanical harvesters were operated in Utah in 1970 and will be used again in 1971. Mechanical pickers operate most efficiently in large fields. The change to mechanical harvesting will eventually force the smaller fields out of tomato production. The one bushel tomato box is fast becoming obsolete, even in fields that are hand-picked. The use of bulk bins greatly facilitates the handling of tomatoes in the field and at the cannery.

FUTURE DEVELOPMENTS

Advancements must take place in all industries if they are to survive in a competitive society. Utah's tomato industry is no exception to this general rule. In the future, we will probably see a shift to mechanization of the two most labor-demanding practices in growing tomatoes. Nearly all of Utah's tomatoes are currently transplanted into the fields. The shift to the direct-seeding of tomatoes has been slow in Utah, not because the equipment is unavailable, but because of the cool

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spring weather in Utah. The tomato varieties used today will not germinate satisfactorily at soil temperatures lower than 65 F. Secondly, the mechanical harvesting of tomatoes will undoubtedly increase. The current tomato varieties and cultural practices used in Utah are not adequate for mechanical harvesting. These machines go through a field only once and destroy the tomato plants in the harvesting operation. For satisfactory harvest by machines, a high proportion of the tomato fruits must ripen at one time and prior to the onset of freezing temperatures in the fall. The cold weather in 1970 reduced tomato yields quite severely. A cool spring delayed the early plant development and cool fall delayed maturity of the fruit, resulting in a low tonnage harvest.

CURRENT RESEARCH

At the present time, researchers at the Utah State Agricultural Experiment Station are developing tomato varieties that will germinate at cooler temperatures. Such varieties will facilitate the direct-seeding of tomatoes, since they will germinate at a lower temperature and begin their growth earlier in the season. Development of varieties that will mature earlier in the season is also underway at the University. The current varieties used

in commercial production do not perform well under Utah's weather conditions. Most varieties developed for mechanical harvesting produce sparse foliage in Utah, which results in the fruit becoming sunburned as it matures. This tendency will be overcome in newer, more leafy varieties.

Growth regulators that will hasten the maturity and concentrate the fruit set of tomatoes are currently being evaluated. Research is underway to evaluate potential growth regulating chemicals under Utah environmental conditions so that recommendations can be made to the growers when the chemicals become registered for commercial usage.

This potential combination of early germinating varieties that will set a high concentration of uniformly mature fruit early in the fall and the possibility of using growth regulating chemicals to enhance maturity, will allow the mechanization of the two most labor-demanding operations of the tomato industry — planting and harvesting. These developments appear to be essential to the economic survival of this important Utah industry and should become realities in the very near future.

TOMATO BREEDING

(Continued from page 3)

breeding program, that approach was used in further developments. A back-crossing program was used to incorporate resistance to these two wilt diseases into varieties being grown in other parts of the country. This resulted in the release in 1959 of two varieties, Pearson VF6 and Pearson VF11, which were used to replace the variety Improved Pearson, which then was the most popular variety in California. The breeding work for these two varieties was done at Logan by Orson Cannon, and the selection of the two for release was carried on at the California Agricultural Experiment Station by G. C. Hanna.

Utah developed varieties have been replaced in Utah by varieties resistant to *Verticillium* and *Fusarium* wilt diseases and which are better suited to harvesting by hand picking. Most of them were developed by Dr. Walter Virgin of the California Packing Corporation. G. C. Hanna used the Utah variety VR Moscow as one parent in developing varieties for machine harvest in California. These varieties have made it possible for farmers in California to plant seed directly in the field and harvest mature tomatoes by machine at a lower cost than can be done in Utah. For this reason it will be necessary to develop varieties for Utah that can compete with those grown in California. We expect such varieties to be available soon.



Figure 1. If cool temperature germinating tomato varieties prove successful in Utah, they can be direct seeded in the field and mechanically harvested.



WITH ETHREL . . .

Hastening green-wrap tomato ripening

D. K. SALUNKHE, J. L. ANDERSON, and J. B. PATIL

Research on the acceleration and inhibition on the ripening processes of tomato fruit by physicochemical treatments has been in progress in our laboratories for over a decade. Studies on the quality of Utah-grown tomatoes for processing was conducted in cooperation with the National Canners Association and Utah Canners Association in 1959 and published in Utah Science in September 1961. Artificial ripening with ethylene gas (100 ppm) of green-wrap tomatoes for shipping to distant markets was studied from 1960 to 1965, and the results were published in Utah Science in June 1965 and in several scientific journals.

Tomatoes are important processing and fresh-market commodities in Utah. Annually, over 20 million dollars worth of fresh and processing tomato business takes place in our state. The year-round utilization of fresh tomatoes exists because they can be harvested at the mature green stage and ripened in transit or at their destination. The demand for tomato fruit is a result of its nutritive value—vitamin C, carotene, and mineral content, and its general eye appeal to the consumer. The acceptance of fresh tomato fruit by the consumer is based upon color and stage of ripeness when displayed in retail markets.

During the winter months, green-wrap tomatoes are transported to Utah from the Southern States and Mexico and ripened at the wholesale centers before they are made available to the retailers and consumers.

As with many other crops, mechanical harvesting of processing tomatoes is *here*, because of the high labor costs

of manual harvesting. The advances in tomato breeding has made "one harvest" of the crop possible. However, a certain percentage of the harvest is immature green fruit which must be ripened and utilized in an attempt to make the enterprise more profitable. With this in mind, the following study was conducted.

Ethrel (2-chloroethylphosphonic acid) is a new plant growth regulator which produces hormone-type re-

sponses in treated plant tissue. Recent investigations have indicated that Ethrel, by degrading to ethylene, accelerates the ripening rate of the green-wrap tomatoes.

ETHREL TREATMENTS

For the post-harvest application of Ethrel, the fruits (cultivar VF 99) were harvested at different intervals, brought to the laboratory, washed, and sorted according to maturity. The

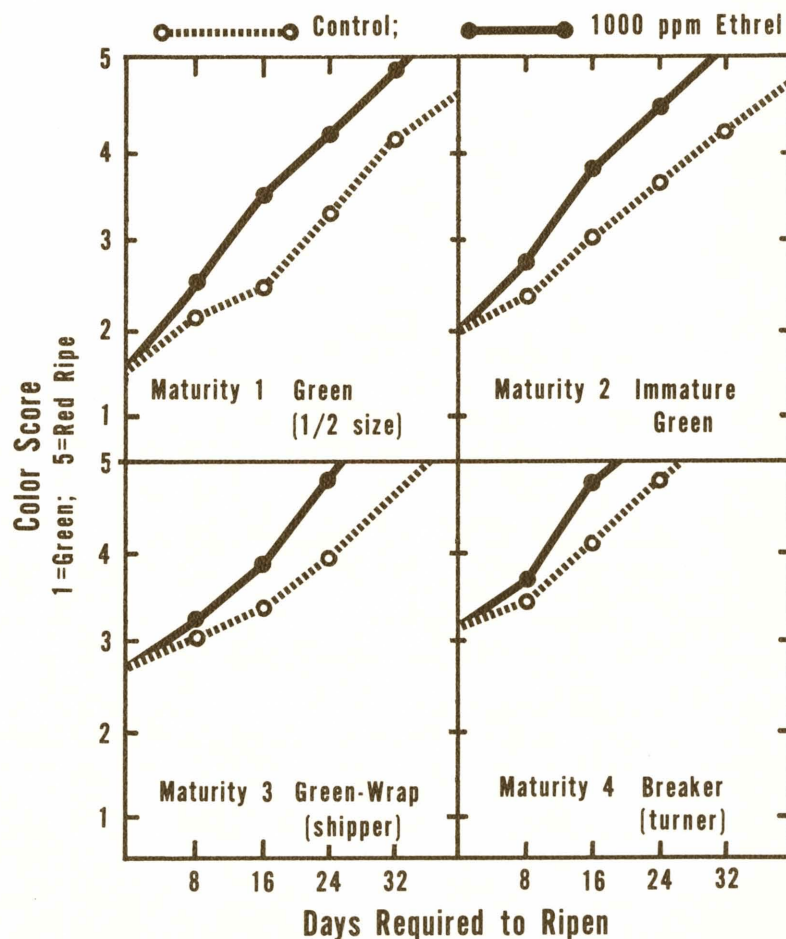


Figure 1. Post-harvest dip of Ethrel (1,000 ppm) on the ripening rate as determined by color development of tomato fruit at the holding temperature of 55 F.

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maturities were determined on the basis of specific gravity and visual color. The fruits which floated in 45 percent ethanol solution were classified as maturity 1 (one-half size whitish-green); in 30 percent, maturity 2 (immature green - greenish - white); in 15 percent, maturity, maturity 3 (mature green-wrap); and in water, maturity 4 (breaker-turner). Fifty tomatoes were selected from each lot and dipped for 2 minutes in Ethrel solutions of 1,000, 5,000, and 10,000 ppm concentrations with four replications each. The tomatoes were ripened at 70 F (ripening temperature) and 95 percent relative humidity and 55 F (a holding temperature in the grocery store) and 90 to 95 percent relative humidity. Daily observations were made on the color development and the ripening rate. A numerical value of color (1 = green, 2 = greenish-white, 3 = green-wrap, 4 = turner-pink, 5 = red-ripe) was assigned to each fruit in a given sample at each observation time. Mean values for each treatment were recorded. Similarly at the end of the experiment, quality attributes such as acidity, soluble solids, and color values were determined by using a pH meter, refractometer, and Hunter color and color difference meter, respectively. Respiratory rates of the representative samples from both treated and control fruits were measured as carbon dioxide evolved by the Claypool-Keefer respirometer.

MEASUREMENTS

Acidity of the fruit, particularly of tomatoes, is very important for flavor. It is also important to the processor because butyric, thermophilic, and putrefactive anaerobic microorganisms find difficulty growing when pH is below 4.3 and if the pH of the tomato is higher (over 5.0) the spores of the microorganisms are difficult to kill. Consequently, acidification of the fruits is essential. Otherwise, processing times and temperature must be increased. This is particularly true for lye-peeled tomatoes.

Soluble solids predominantly constitute the sugars in tomatoes. The

higher the concentrations of soluble solids the better the flavor and the shorter the time required to make paste during concentration for ketchups.

The color of both fresh and processed tomatoes is important to the consumer because he buys fresh as well as processed products by appearance and by the reputation of the product brand. The color of the tomato is caused by lycopene, carotene, and the ripening processes of the fruits.

RESULTS

The results of the post-harvest treatments at the holding temperature of 55 F and 95 percent relative humidity indicate that there was little difference between tomatoes of maturity 3 (green-wrap) and 4 (pink)

in regard to their ripening rates when treated at the concentrations for 1,000 to 10,000 ppm. There was a definite difference, however, between the untreated fruit and those treated with 1,000 ppm Ethrel. Hence, only the control and those treated with 1,000 ppm of Ethrel data are presented (figure 1). There was also slight difference in the ripening behavior of maturity 1 and 2 tomatoes. As the concentration of Ethrel increased, there was an increase in the ripening rate of maturity 2 tomatoes. In green-wrap tomatoes, there was a significant change from the untreated to 1,000 ppm concentration. In maturity 4 tomatoes, the ripening rates among various concentration levels did not show significant difference. In other words, pink tomatoes did not show as great a response as other maturities except in uniform color development. In general, the ripening rate with Ethrel

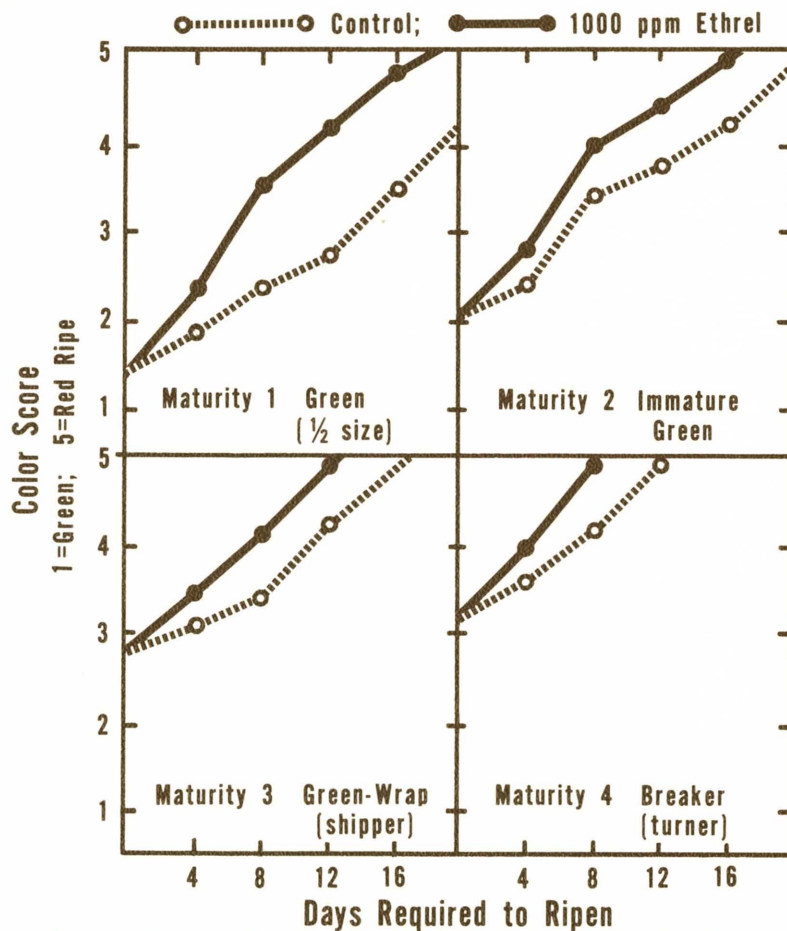


Figure 2. Post-harvest dip of Ethrel (1,000 ppm) on the ripening rate as determined by color development of tomato fruit at the ripening temperature of 70 F.

(1,000 ppm) increased by a week at 55 F over the comparable untreated controls.

The results of ripening at 70 F and 95 percent relative humidity (figure 2) at the 1,000 ppm concentration indicated that the green tomatoes of maturity 1, 2, and 3 developed better and more uniform color 4 days earlier than the untreated controls. Higher concentration of Ethrel did not accelerate ripening rates significantly.

EVALUATIONS AND CONCLUSIONS

Table 1 indicates that there was no significant difference in the quality factors such as color, acidity, and sweetness of the control fruits and those treated with 1,000 ppm Ethrel. Respiration of the treated fruits as measured with the Claypool-Keefer respirometer indicated that Ethrel accelerated respiration rates of green tomatoes by 10 percent and of pink tomatoes by 2 to 3 percent when compared with the untreated controls. The accelerated respiration accelerated the ripening rate.

The significance of these findings is that Ethrel accelerated the ripening process of tomatoes resulting in a more intense and uniform color development than occurred in untreated fruit. Tomato yields from mechanically-harvested fields in Utah have at times been disappointing, especially when the harvest season has been cooler than normal. Low yields have resulted when tomato fruit has not rapidly ripened because of cool temperatures but must be harvested because of frost hazards or unavailability of harvesting machines. The use of post-harvest dip of Ethrel offers tomato producers an opportunity to obtain a marketable tomato from fruits that heretofore have been too immature to market or to process.

Table 1. The effects of post-harvest Ethrel dip (1,000 ppm) on the ripening of tomato fruits of four maturities. (Readings were taken in duplicates at the end of the experiments)

Maturity	Treatment	55 F					70 F				
		pH values	Total soluble solids (%)	Hunter color measures*			pH values	Total soluble solids (%)	Hunter color measures*		
				L	a	b			L	a	b
Whitish-green (½ size)	control	4.3	4.0				4.3	4.2	32.15	26.15	13.55
	Ethrel	4.3	4.0				4.4	4.5	30.50	27.30	13.45
Immature green (greenish-white)	control	4.3	4.7	34.40	20.80	15.15	4.3	4.5	32.40	24.15	15.25
	Ethrel	4.3	4.9	33.65	22.20	15.20	4.3	5.0	32.25	26.65	14.30
Green-wrap	control	4.1	4.5	33.00	25.90	15.30	4.4	4.5	31.60	27.85	13.05
	Ethrel	4.2	5.0	34.30	24.70	14.50	4.4	5.0	30.55	25.40	12.40
Turner (Breaker)	control	4.2	4.7	34.10	24.05	14.20	4.3	5.0	31.10	25.65	12.75
	Ethrel	4.2	5.0	33.70	24.25	14.65	4.3	5.5	32.25	26.15	12.15

*Standard tomato color tile with readings of L=24.45; a=24.26; b=11.5

L denotes lightness; a denotes redness; and b denotes yellowness of the tomato puree.

EARLY MATURING, LOW TEMPERATURE GERMINATING TOMATOES FOR UTAH

ORSON S. CANNON

Developments of the last few years have made it possible for tomato growers in California to produce abundant crops of tomatoes with much less labor than previously. Tomatoes which at one time were produced by transplanting partly grown plants and then harvesting them by hand at intervals as the crop ripened, now are seeded directly in the field and mechanically harvested. The need for hand weeding is eliminated by use of herbicides applied before seeding; and when approximately 70 percent of the fruits are ripe, the plants are cut off, the tomatoes shaken into a conveyor belt and emptied into the containers in which they will be carried to the canning factory. The machine doing the harvesting does the job for much less than it can be done by people.

Admittedly, most tomato varieties require a soil temperature of near 60 F to germinate. California is better suited to machine harvesting of tomatoes than Utah because of its long growing season. The soil becomes

warm enough for planting earlier in the spring, and tomatoes can be planted over a period of several weeks without the danger of the crop being frozen in the fall before harvest.

In Utah, however, the soil warms up slowly in the spring. As a rule, tomatoes grown by direct seeding rarely have 50 percent of the crop ripe by mid-September, often when killing frosts occur. So it is evident that if Utah is to continue to raise processing tomatoes competitive with California, growers either will have to transplant and machine harvest or try other approaches to meet the economic squeeze.

One of the approaches we are using at Utah State University is the development of varieties that have the ability to germinate at lower temperatures. If the ability to germinate at low temperatures can be combined with early harvest, it is probable that several varieties can be developed that will germinate in our cool spring soils,

(Continued on page 23)

FOR MECHANICAL HARVESTING . . .

Accelerating tomato maturity with Ethrel

J. LAMAR ANDERSON and ORLIN LUSK

Ethrel (2-chloroethyl phosphonic acid) has growth regulating activity similar to the action of ethylene. It accelerates post-harvest ripening of tomatoes, bananas, and other fruit. It induces flowering in pineapple, causes female flower differentiation in cucumbers, and acts as a thinning agent by accelerating abscission of flowers and young fruit in certain trees. It also can be an aid to mechanical harvesting by loosening fruit at harvest. The following experiments were initiated to determine the effects of Ethrel on accelerating and concentrating the maturity of tomato fruit on the vine under field conditions.

The herbicide diphenamid was soil incorporated into the tomato plots at the Farmington Field Station prior to planting. Tomatoes (cv. VF 145) were direct seeded into the plots with a Stanhay precision planter on April 24, 1970. Ethrel was applied at two different stages of maturity. The first application was made on August 21, when 1 percent of the fruit showed a color break or pink stage. A second series of plots were treated on August 28, when 20 percent of the fruits had reached the pink stage. Ethrel was applied at two rates, 0.83 lb. per acre and 1.66 lbs. per acre at the 1 percent pink stage, and at three rates, 0.42 lb. per acre, 0.83 lb. per acre, and 1.66 lbs. per acre at the 20 percent pink stage. Plots were mechanically harvested by shaking all fruit from the vines at either 1 or 2 weeks after treatment. Each treatment (rate x type of application x time of har-

est) was replicated three times. Harvested fruits were segregated into green, pink, ripe, and over-ripe stages.

The total yield of tomato fruit was not significantly affected by Ethrel application. All plots averaged about 30 tons per acre total fruit. Ethrel hastened the ripening process of tomato fruit and the percentages of fruit in

the red ripe and pink categories were significantly greater in the early harvests from the Ethrel treated plots than they were from the untreated plots.

The rate of ripening of Ethrel treated fruit is more rapid than untreated fruit, but in each case the rip-



Figure 1. Note the number of green tomatoes in the once-over harvest of the control plot.



Figure 2. The Ethrel-treated plot yielded a higher percentage of "breakers."

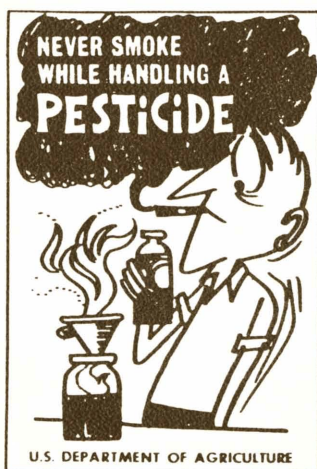
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ening rate is regulated by temperature. Laboratory studies have shown that treated fruit ripen much more rapidly at 65 F than at 50 F. Field temperatures during the period of tomato ripening (August 20 through September 20) were cooler in 1970 than is normally expected for this time of year. This delayed the maturity of all plots, and had an early frost occurred, the untreated plots might well have been frozen before a sufficient number of fruit were ripe enough to justify harvest.

There was some yellowing and senescence of leaves observed after the Ethrel applications, especially at the 1.66 pound rate. The VF 145 and related tomato varieties tend to sunburn under Utah conditions. The senescence of the tomato foliage at high Ethrel rates tended to increase slightly the amount of sunburning of VF 145. Other than the slight increase in sunburn, the Ethrel treated fruit was indistinguishable in quality from fruit of the control plots.

Ethrel is not available for commercial use on tomatoes yet and research is continuing to determine its usefulness to agriculture. It appears that Ethrel has a good potential to hasten ripening of tomatoes and thereby allow the tomato processor a programmed harvest.



1970 TOMATO YIELDS

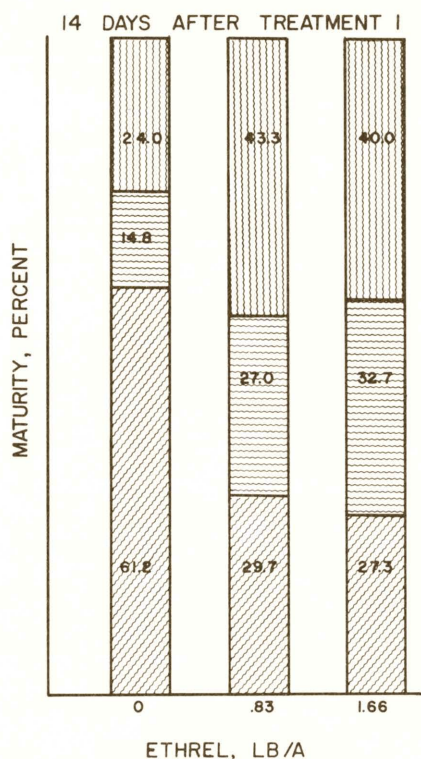


Figure 3

1970 TOMATO YIELDS

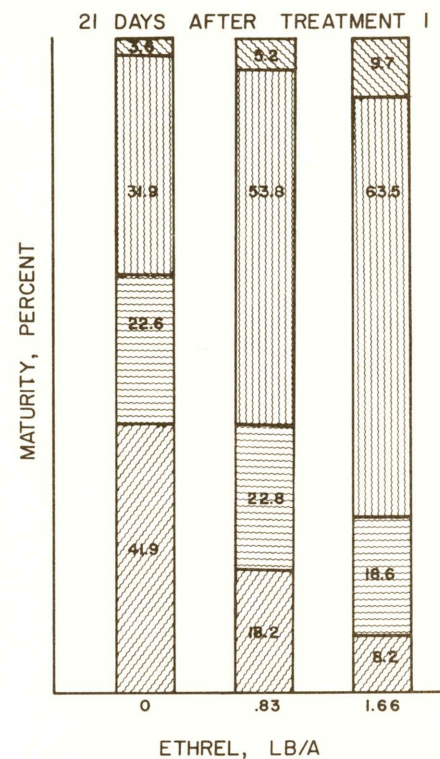


Figure 4

1970 TOMATO YIELDS

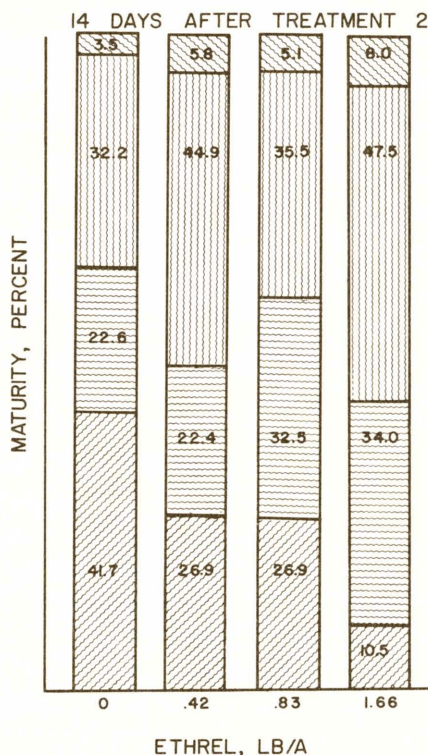


Figure 5

1970 TOMATO YIELDS

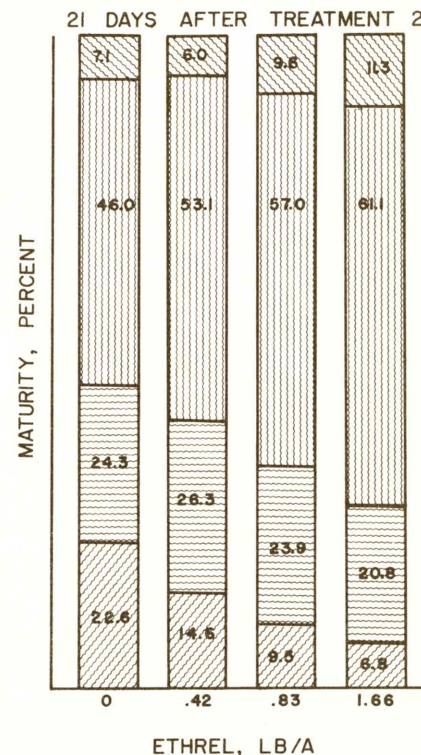


Figure 6

Weed control in tomatoes

J. LAMAR ANDERSON

Weeds plague man by disputing his efforts to regulate and achieve the highest yields of desirable plants. Man's confrontation with weeds is a never ending one and today, weeds remain as the costliest enemy to the producer of food and fiber. Average losses caused by weeds are in excess of 5 billion dollars annually. It has been estimated that in spite of weed control efforts using modern methods of increased efficiency, the American farmer is still losing 13.5 percent of his annual crop production because of weed competition.

The tomatoes grown in the United States today are a much different fruit from those grown by Thomas Jefferson, who first recorded tomato culture in the United States in 1781. The cultural practices employed in this production also have changed drastically, but the need for effective weed control for tomato reproduction is as essential as it ever was. The tomato, especially in its young seedling stages, is a poor competitor with the weeds

that naturally infest our agricultural acreages. If the farmer is going to successfully produce a profitable tomato crop, he must adjust the agricultural environment to favor the tomatoes rather than weeds.

Chemical weed control has been an effective tool for the farmer since 1945. The Utah Agricultural Experiment Station has been investigating the use of herbicides to control weeds in tomatoes since 1960. No single herbicide has been found, however, that will control all the weeds. Therefore, herbicide usage does not eliminate the need for timely cultivation, and often hand weeding is necessary. In fact, the use of herbicides can be justified only where their use costs less than the more conventional methods of weed control.

The herbicides that have given good weed control in our experimental trials and are available in Utah for the to-

mato grower include diphenamid (Dymid, Enide), pebulate (Tillam), and trifluralin (Treflan). All of these are most effective when they are incorporated into the tomato bed with a power driven rotary tiller prior to planting. Incorporation with disks or harrows has often resulted in poor control.

Diphenamid has been widely used for weed control in direct-seeded and transplant tomatoes. In many trials and in commercial fields where 4 to 6 pounds of the active ingredient have been incorporated per acre, it has effectively controlled annual grasses and certain broadleaf weeds. Plants in the tomato family, including "nightshade," are tolerant to diphenamid. As a result, nightshade often thrives in treated plots. Diphenamid also gives incomplete control of shephard's purse, mallow, and common sunflower. In addition, this particular herbicide is quite soluble and tends to leach in sandy soils. This is especially true when high amounts of rain-

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Table 1. 1969 effects of preplant incorporated herbicides on direct seeded tomatoes¹

Herbicide	lb/A	5/23		7/1		Phytotoxicity
		weed control	weeding time	weed control	weeding time	
diphenamid	5	8.0	3-1/2 min	7.3	7-3/4 min	2.3
diphenamid + pebulate	4 + 3	9.7	1-3/4 min	9.5	6-1/2 min	6.7
trifluralin	1/2	8.0	4-3/4 min	7.5	3-1/2 min	5.7
trifluralin + diphenamid	1/4 + 4	8.7	2-3/4 min	9.0	4 min	2.8
trifluralin + pebulate	1/4 + 3	9.7	2-1/2 min	9.5	5-1/2 min	4.7
EL 179 ²	1-1/2	8.0	4 min	7.3	3-1/2 min	4.0
EL 179 ²	3/4	6.8	5-1/2 min	6.0	5-3/4 min	3.3
Control		0	24-1/2 min	0	11-1/2 min	0

¹ average of six replications

² average of three replications

Table 2. 1970 herbicide effects on tomato weed control¹

Treatment	lb/A	July 2, 1970		August 18, 1970	
		Weed control rating	Weeding time	Weed control rating	Weeding time
amiben	3	3.5	4:44	7.5	1:12
DCPA	8	7.5	2:28	8.5	:52
diphenamid	5	5.5	4:50	7	1:40
diphenamid + trifluralin	4 + 1/4	8.8	2:07	9.5	:39
EL 179	1	6.0	3:38	9	:47
pebulate	4	7.0	3:07	7.5	1:22
planavin	1/2	7.0	3:28	9	:49
trifluralin	1/2	6.0	3:44	9.5	:39
trifluralin + amiben	1/2 + 1/2	7.0	3:50	9	:45
untreated control		0.7	9:24	4	2:10

¹ average of four replications**Table 3.** 1970 tomato response to herbicide treatment¹

Treatment	Rate	phytotoxicity	Yield (tons/A) ²	
			Transplants	Direct seeded
ambin	3	4.2	15.36	4.25
DCPA	8	6.3	18.84	5.04
diphenamid	5	1.2	14.96	7.84
diphenamid + trifluralin	4 + 1/4	1.5	21.17	12.85
EL 179	1	2.7	15.56	9.51
pebulate	4	2.7	16.12	7.17
planavin	1/2	3.2	17.89	7.44
trifluralin	1/2	3.2	17.53	7.95
trifluralin + amiben	1/2 + 1-1/2	3.7	17.32	5.95
untreated control	3		10.56	4.97

¹ average of four replications² tonage is the average total yield of eight hand pickings of transplants and five hand pickings of direct seeded plots.

fall occur shortly after treatment, as happened in northern Utah 1970 or when excessive amounts of irrigation water are applied. As a result, weed control with diphenamid in 1970 was less than satisfactory.

Pebulate is a volatile herbicide, and it is essential that it be incorporated into the soil immediately after application. Pebulate has given good weed control of annual grasses and many annual broadleaf weeds when properly placed into well prepared seed beds that are free of large clods, at 4 pounds active ingredient per acre. Pebulate is also used on both trans-

plant and direct-seeded tomatoes in Utah. Injury to tomato seedlings has been observed in sandy soils in Utah during cool, wet springs, however.

Trifluralin, at one-half pound active ingredient per acre, has given excellent control of all annual grasses and many broadleaved weeds in transplant tomatoes. It is quite insoluble and tends to breakdown in direct sunlight, so it must be thoroughly mixed into the soil for satisfactory weed control. Nightshade is resistant to trifluralin and shepherd purse is also somewhat tolerant. Trifluralin generally has given better weed control than either

diphenamid or pebulate in our trials. Retardation of the secondary root development and delayed growth of the first true leaves of tomato seedlings have been observed in plots treated with trifluralin or related materials. Tomatoes tend to outgrow this early set back, however, and yields are seldom affected. Weed competition causes more severe and longer lasting retardation of growth in the growth of young tomato plants than is caused by these herbicides.

Because of its possible toxicity, the 1/2 pound rate of trifluralin cannot be recommended in Utah for direct-seeded tomatoes. A combination, however, of trifluralin at 1/4 pound and diphenamid at 4 pounds of the active ingredients per acre has given excellent weed control in direct-seeded tomatoes without seriously reducing tomato growth. This combination of diphenamid and trifluralin has given the best weed control in transplant or direct-seeded tomatoes where nightshade or other resistant weeds do not predominate. However this combination has not been registered for use on direct seeded tomatoes in Utah and therefore can be recommended only for transplanted tomatoes at the present time.

Weed control recommendations are revised periodically and are published as Utah State University Extension Circular 301. These recommendations may be obtained from the USU Extension Agent Offices or the Extension Bulletin room at Utah State University.



PROTECT your HOME and GARDEN where 15 percent of all pesticides purchased are used to help preserve a healthy, attractive, productive environment for work and play.

Bacterial Canker of Tomatoes

In 1970, bacterial canker of tomatoes was observed in many home gardens and in the fields of some commercial tomato growers in Utah. Bacterial canker has occurred occasionally in nearly all major tomato growing areas of the United States. If sufficient safeguards are not taken, it can become very destructive. In fact, it caused widespread destruction in Utah tomato fields in the decade from 1925 to 1935. Investigations carried on by the late H. Loran Blood lead to the development of control measures that eliminated the disease from most tomato growing areas.

Bacterial canker is caused by a bacterium *Corynebacterium michiganense* (E. F. Sm.) Jensen, that attacks and disorganizes the vascular elements in the leaves, stems, and fruits. The earliest symptom is a unilateral wilting of the leaves. This is followed by a breakdown of stem tissues, leaving a mealy yellow mass from which the pith may be separated easily. A yellowish milky ooze may be obtained by squeezing petioles of detached diseased leaves.

Plants that are infected while they are young die quickly. An occasional stem may escape infection and grow to produce an apparently healthy branch bearing fruit, but eventually all such branches wilt and die. If plants are older when infection occurs, one or more branches become flaccid, crumple, and die, while the rest of the plant appears normal. As the season progresses, the healthy branches also become diseased. Plants infected early in the season rarely produce ripe fruit. Those infected in mid-season occasionally produce some poor quality fruits. A partial crop may be produced by plants infected late in the season. Regardless of when infection occurs, however, much of the crop is destroyed.

Dr. Blood developed methods of controlling bacterial canker, and the general adoption of his methods elim-

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inated it as a serious disease in Utah tomato fields for many years. Dr. Blood's control program was based on the use of clean seed, clean seedbeds and seedbed soil, and clean fields in which the crop is grown.

CLEAN SEED

In diseased plants the bacteria which cause the disease penetrate the developing seeds and are contained within them when the seeds mature. Since the bacteria are within the seeds, a surface germicide cannot reach them and kill them. As a result they are present when the seeds begin to grow, and seedlings produced from such seeds become diseased. Bacteria multiply in and on the diseased seedlings and are splashed to healthy by rain water or irrigation water; thus healthy plants become infected. In this way a few infected seeds provide inoculum that can contaminate many plants and results in their infection.

Dr. Blood found that the bacteria can be eliminated from seeds in two ways: (1) by extracting the seeds by fermenting the crushed fruits for 96 hours and then washing the pulp from the seeds; or (2) by treating the extracted seed with acetic acid.

In extracting seeds by fermentation, the fruit should be thoroughly crushed. Then the juice and pulp containing the seeds should be set aside and allowed to ferment at a temperature not over 70 F for 96 hours. The fermenting juices should be stirred at least twice daily to submerge the pomace that floats to the top.

Seed extracted by mechanical means without fermentation should be treated immediately at a temperature

below 70 F by soaking for 24 hours in an 0.8 percent solution of acetic acid. The seed may be treated loose or confined in a cheesecloth bag for easier handling. It should be agitated thoroughly to insure uniform wetting at the beginning of the treatment.

Both fermentation and treatment with acetic acid will result in some reduction in germination. However, it will be negligible if the temperatures are kept near 70 F and the seeds are dried in warm air at a moderate rate immediately after treatment.

SEEDBED SANITATION

When even a slight amount of disease has occurred in plants from any seedbed, that bed should be thoroughly reconditioned by replacing the old soil to a depth of at least 10 inches with virgin soil, and the frames and covers should be washed and the subsoil thoroughly drenched with a solution of formaldehyde. The solution consists of 1 gallon of formaldehyde (40%) in 24 gallons of water.

If soil in coldframes and benches cannot be replaced, it may be drenched with the formaldehyde solution. Apply 1 quart of solution to each square foot of soil, water heavily to thoroughly wet the soil and then cover it for 5 days with a polyethylene tarp. After removing the tarp, work the soil to speed the escape of the formaldehyde vapor and allow it to stand for at least 10 days before planting. Formaldehyde is very toxic to living plants, so it should never be used when the fumes will reach living plants growing nearby.

FIELD ROTATION

To avoid the carry over of the bacterial canker organism in the field it is advisable to have at least a 3-year rotation, because the bacteria which cause bacterial canker are known to survive in soils for at least 2 years.

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GREENHOUSE TOMATO PRODUCTION

DAVID R. WALKER

Growing tomatoes and other vegetables in greenhouses during the winter is certainly nothing new, but commercial applications have been slow to catch on in the West. The center of the vegetable greenhouse production in the United States has been in the Northeastern area, with only very limited acreage in the West. There has been an increased interest the last few years, however, in developing a larger vegetable greenhouse industry in the Southwest. This area has mild winter temperatures, high light intensity and low humidity, which are desirable conditions for greenhouse vegetable production.

Greenhouse tomato production in Utah has been nil until the last 3 years. Presently, there are approximately 20 greenhouse enterprises in the state with several other operators considering the venture. The operations in Utah are relatively small compared to those in the East. Many units are only 40 feet by 120 feet — 1/9 acre. There are only five operations of 1/2 acre or more. An estimated 5 acres of greenhouse tomatoes are grown in Utah at present. This acreage will likely double by the end of 1971.

WINTER IMPORTS

A large number of tomatoes are shipped into Utah during the winter. Most of the tomatoes are grown in western Mexico, about 700 miles south of the border. They are grown in the field and harvested from December through April. Field tomatoes from Southern California, Texas and even Florida are shipped into Utah late in the fall and early spring to supply the market. These tomatoes are harvested before they have developed optimum maturity, transported many miles, and handled a number of times before they are available to the consumer. Such tomatoes

are somewhat lacking in color, flavor, and texture when compared to those grown locally in season.

In contrast to the imported field grown type, greenhouse tomatoes are grown in an optimum environment, harvested at the ideal maturity and are on the grocer's shelf 1 or 2 days after they are picked. The Utah grown greenhouse tomatoes are equal and usually much better in quality to those imported during the winter period. Produce dealers have indicated a preference for the greenhouse tomato and are willing to pay a premium for them.

GREENHOUSE PROBLEMS

Producing tomatoes in a greenhouse is a difficult and complex enterprise—a greater challenge than marketing them at this time. The reverse is true with most agricultural products. The largest problem is providing optimum temperature and ventilation. A fungus disease, *Botrytis*, develops under humid conditions and low temperatures. Another fungus disease, leafmold, develops under humid conditions and high temperature. These diseases can reduce the crop substantially. *Botrytis* can almost eliminate a crop within a 2 or 3 week period if high humidity and low temperature prevail. It is necessary to keep the air circulating within the greenhouse and bring in outside air to reduce the humidity to avoid *Botrytis*.

Coverings for greenhouses have included fiberglass, glass or plastic. The majority of the growers in the West are using fiberglass. It is cheaper than glass and has worked well. Some have used plastic covering. Plastic, however, deteriorates in sunlight and needs to be replaced each year. It

also is susceptible to wind and snow storms. Unless fastened securely, winds can strip it from the building frame. Growers with plastic houses raise the temperature to melt the snow and often use two layers of plastic and blow air between the layers for insulation. The air pressure provides tight plastic against strong winds. The second layer offers additional security in case the top layer of plastic should blow off. Growers with fiberglass also use a thin layer of plastic inside their greenhouses to reduce heat losses. The cost of labor and materials for those using plastic is about the same as those using fiberglass over an 8 to 10-year period. Using plastic is an economical method of starting in the greenhouse business, but the loss of one crop caused by wind stripping away the plastic covering would more than pay for fiberglass.

GROWING MEDIUM

Tomatoes may be grown in gravel, cinders, peat moss and vermiculite, or soil. Unless there are soil borne diseases which cannot be controlled or poor soil structure or texture, it is cheaper to grow crops in soil than by hydroponic culture. Using this method, tomatoe plants are grown in gravel and water that has had fertilizer added to it. Beautiful young plants can be grown by this method, but when the plants become 7 to 8 feet tall and the fruits are enlarging, it is difficult to supply sufficient water and minerals to the plants by this method. Blossom end-rot may develop, and often the fruit does not become as large as when grown in soil or an artificial soilmix. Using a soilless media, however, does not alter the tomato quality from those grown in soil. It also is difficult to maintain the proper nutrient balance when using the hydroponic culture method. The water is usually recirculated to the plants for a 2-week period

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before being changed. During this time some nutrient elements are absorbed more rapidly than others. This results in a pH change and some chemical complexing such that nutrients become unavailable to the plant.

PLANT CULTURE

Utah operators can grow two tomato crops a year in the greenhouse. Seed for the fall crop is planted in mid-June, seedlings are transplanted in the greenhouse in late July, and they bear fruit from late October until early January. The spring crop seed is planted in late November, seedlings are transplanted in mid-January, and the plants bear fruit from early April through mid-July. Light is limiting in late November. The tomato flowers do not sell well, and the plants stop developing fruit for the winter period. Because of this cropping system, Utah growers do not have tomatoes available from mid-January through early April. During this period the Mexican grown tomatoes are available. Thus, they are fortunately not in competition with imported produce.

Growers average one plant per 3 or 4 square feet. They plant from 10,000 to 14,000 plants per acre. Plants are spaced further apart in the fall than in the spring to allow exposure to adequate sunlight. The plants are pruned weekly and trained to a single stem supported by stringes hanging from overhead wire. The plants produce nearly twice as much fruit in the spring as in the fall. The spring crop has a longer period to produce fruit and better light conditions. Experienced growers aim for an average of 5 pounds per plant in the fall and 10 pounds in the spring. These yields have been doubled, but that is not common. Growers with heat or ventilation problems may market half or less than this amount.

Based on the experience thus far, greenhouse tomato production in Utah can be a profitable or an expensive experience depending upon the initial investment and the cultural management. Growers must have a good understanding of plant growth factors, greenhouse requirements, and provide optimum growing conditions to be successful.

FROM BABY FOOD TO SPACE FEEDING — — —

Freeze-dehydrated applesauce has potential

D. K. SALUNKHE, Y. S. LEE,
and H. R. BOLIN

Applesauce has long been considered an important food product in the United States. More than 25 percent of the fresh apples used by the food industry in the United States are converted into sauce. Many reports have indicated that the quality of canned applesauce depends upon the cultivar characteristics, stage of maturation, and post-harvest storage of the apples. A large portion of the crop has been utilized for sauce manufacturing because fruit from the desirable apple cultivars can be blended and its fine particle character has advantages as a baby food.

In recent years, freeze-dehydrated fruits and fruit products have been manufactured in an attempt to remove most of the water they contain while maintaining the natural quality of the products. Freeze-dehydrated foods can be stored and transported without refrigeration; they are light in weight and low in volume; are convenient for handling and packaging; rehydrate readily; and they have improved stability. These advantages, along with the excellent flavor retention capacity, have made freeze-dehydrated products important among processed foods. Therefore, an attempt was made to evaluate the quality of freeze-dehydrated applesauce.

Three important cultivars of apples grown in Utah, Jonathan, Delicious, and Rome Beauty were selected for this experiment. The fruits, of uniform maturity and size, were obtained from the Utah State University Experiment Station at North Ogden, Utah on September 15 through 20, 1964. Apples were then stored at 32 F and 90 percent relative humidity for 2 months. Subsequently, sauce was made and canned according to a standard commercial method used by Pacific Northwest Processors. Freeze-dehydrated applesauce was prepared by using the Hull Freeze Dehydrator manufactured by the Hull Corporation, Hatboro, Pennsylvania.

CANNED APPLESAUCE

Apples were washed, peeled, cored, sliced, and held in a 1.5 percent sodium chloride solution to prevent enzymatic browning. They were then pre-cooked in a steam-jacket kettle at 210 F for 3 minutes with a small amount of water added (10 ml/lb slices) to prevent scorching. They cooked for 15 minutes. The cooked slices were then comminuted by a Fitzpatrick mill and passed through a screen with 0.062-inch-diameter apertures. The sauce was weighed and sugar was added to adjust the soluble solids to 18 percent by using a refractometer. The finished sauce was conveyed to a filler and sealed in plain tin cans (401 x 403) at 190 to 200 F. Following the 10 minutes in boiling water the cans were cooled

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and stored at 32 F until further analysis. The flow diagram is shown in figure 1.

For the freeze-dried product, the finished sauce was spread onto aluminum plates (15 x 10 x 0.2 inches). Liquid nitrogen (-320°F) was evenly poured onto the sauce to quick-freeze the product. The plates containing the sauce were transferred into the freeze-dehydrator. It took about 15 hours to complete the drying. The vacuum in the chamber was reduced from 120 to 40 microns of mercury. The product temperature increased from -20°F to 140°F . The plate temperature ranged from 70° to 170°F (figure 2). Later the dehydrated applesauce was powdered and packaged under vacuum. It also was held at 32°F for analyses.

QUALITY COMPARISON

The amount of distilled water needed for reconstitution was determined according to the weight reduction after sauce had been freeze-dehydrated (table 1). Hunter color values were measured with a Hunter color and color difference meter. The reference was a standard white plate with $R_d=86$, $a=0.6$, and $b=+1.2$. The R_d = higher value represents the higher degree of luminous reflectance; the a =higher value represents higher degree of redness; and the b =higher value represents a higher degree of yellowness. Volatiles reducing substances (VRS) in applesauce (canned and freeze-dried were determined). Total acidity was determined from a 10-gram sample of applesauce (canned and reconstituted freeze-dried) mixed homogeneously with 100 milliter of distilled water and titrated to 8.1 pH with 0.1 N NaOH. The titratable acidity was expressed as percent malic acid.

Both the canned applesauce and reconstituted freeze-dehydrated applesauce were evaluated for color, flavor, and texture by a trained panel of 10 judges consisting of five men and five women, all non-smokers. Mean ratings are presented in table 2.

RESULTS

With freeze-dehydrated applesauce,

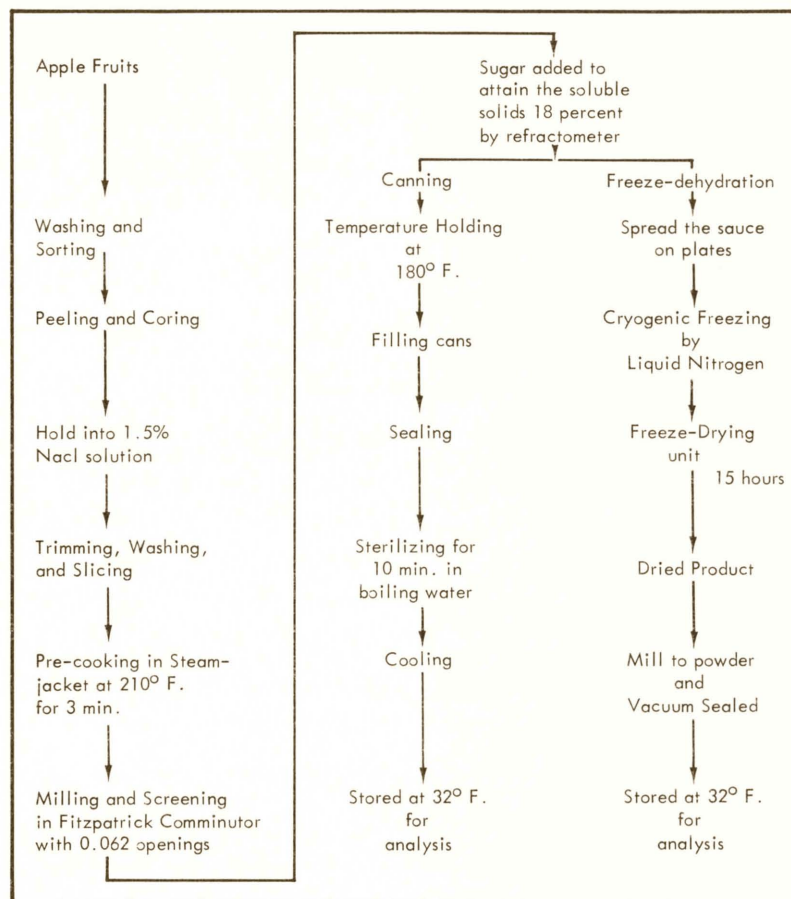


Figure 1. Flow diagram for the preparation of canned and freeze-dehydrated applesauce.

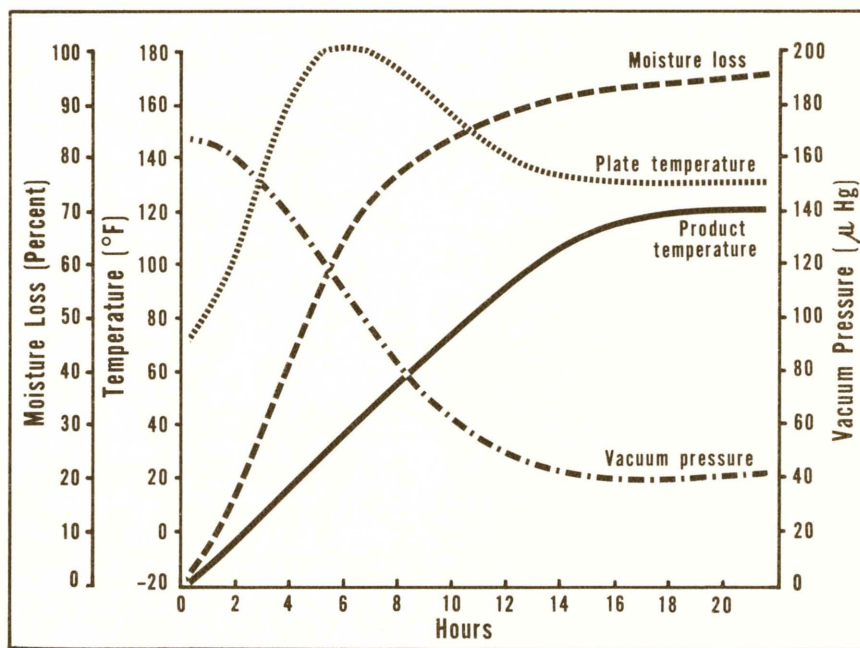


Figure 2. Typical drying curves for applesauce show plate and product temperature, vacuum change, and moisture loss in relation to time.

Table 1. Moisture reduction of freeze-dehydrated applesauce from three cultivars

Cultivars	Percent moisture in fruits before dehydration	Percent moisture removed
Jonathan	80	95.86
Delicious	83	87.35
Rome Beauty	81	93.40

Table 2. Quality comparison between canned and reconstituted freeze-dehydrated applesauce^a

Quality factors	Jonathan		Delicious		Rome Beauty	
	Canned	Freeze	Canned	Freeze	Canned	Freeze
Hunter color						
Rd	47.5	46.3	40.5	41.6	40.2	38.5
a	3.5	4.2	2.0	3.5	3.0	2.6
b	18.0	17.0	15.0	13.8	15.5	16.0
VRS ^b	225.0	220.0	251.4	234.1	281.0	260.0
Acidity ^c	0.55	0.54	0.25	0.26	0.45	0.43
Appraisal score ^d						
Color	9.0	9.0	8.1	7.5	8.4	8.5
Texture	8.5	6.0 ^e	8.0	6.5 ^e	8.0	6.5 ^e
Flavor	8.8	8.5	7.8	7.0	7.8	8.0

^aReconstituted freeze-dehydrated applesauce was prepared by the addition of distilled water in the amount according to weight reduction.

^bVolatile reducing substances expressed a equivalent per 100 gram of sauce.

^cExpressed as percent of malic acid.

^dAppraisal scores were the average of ten judgments.

^eSignificant at 1 percent level.

it was found that most of the free moisture could be removed successfully by the freeze-dehydration. Liquid nitrogen can be used to freeze the sauce quickly. About 95 percent of the moisture could be removed from the sauce of Jonathan apples while the sauce of Delicious apples showed less desirable characteristics. Perhaps this was caused by the higher water holding capacity in cells of Delicious acting as a barrier to sublimation.

Freeze-dehydrated applesauce was compared favorably for quality with canned applesauce of USDA Fancy Grade. Slight variations in color acidity, and volatile reducing substances as well as organoleptic evaluation were noted. The statistical sig-

nificant difference failed to indicate dissimilarity between canned and reconstituted sauce. Although freeze-dehydrated applesauce had a fresh apple flavor, the texture appraisal score of the reconstituted sauce was low for all three apple cultivars. The destruction of cell structure during dehydration may have caused this result. Perhaps the reconstituted sauce did not have the same consistency as the original sauce. The texture may be improved by adjusting the amount of water.

The freeze-dehydrated applesauce prepared similarly complies with NASA requirements for space food and has been used successfully in Apollo space flights.

WILDLIFE NOTES

Mushrooms deadly enough to kill a human are relished by red squirrels during summer months.

A pair of condors produces only one young bird every other year.

Wolverine fur does not accumulate frost and freeze to human skin at 60 to 70 degrees below zero. For this reason it is used by Eskimos on their parkas around the face and wrists.

The pouch of the brown pelican, consisting of tough elastic tissue, is used as a carryall for captured fish.

Almost all the houseflies that live through the winter are fertilized females, ready to lay eggs the following spring.

Male pupfish are colorful, with iridescent blues and purples on their backs and sides, and with black bars and dark fin edges. Females are mottled brown, and usually smaller and slimmer than males.

Sockeye salmon head for the open sea after a year's growth in fresh water, and return four years and 4,000 miles later to spawn at the spot of their birth.

Unlike the Bald Eagle, which scavenges for carrion, the golden eagle hunts live prey and is strong enough to kill a Canada goose.

An adult female cicada, or locust, lays up to 600 eggs in the bark of small branches and twigs. Upon hatching, the young nymphs fall to the ground and burrow until they find a suitable root from which they suck juice.

A lobster sheds its shell 14 to 17 times during its first year.

The eggs of a Bald Eagle take from 30 to 40 days to hatch.

Water Quality Determines Quality of Canned Products

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Natural and industrial pollutants can make culinary water supplies unfit for food processing. Water in Utah and throughout much of the West contains substantial amounts of calcium, magnesium, iron, copper, sulfur, and other minerals. Sulfur compounds in water can cause detinning and subsequent corrosion of the cans. They precipitate due to polymerization and can cause scum and cloudiness in brine or syrup. Iron and copper compounds combine with tannins in fruits and can cause blackening. Sodium, calcium, and magnesium sulfates give bitter flavor to the processed fruits and vegetables. The calcium and magnesium chlorides cause hardness of water. All of these constituents will affect flavor quality of the processed products.

Impurities cause processing problems and considerable economic loss. Consequently, processors pay heavy penalties for using hard water, and consumers receive inferior quality products.

To meet U.S. Public Health Standards, processing water can be softened with water softeners or ion-exchange resins. These chemical water softeners can benefit home canners as well as commercial processor.

The use of hard water for canning fruits and vegetables influences the quality of the processed product. When hard water is used for canning, firmness is retained better in certain fruits and vegetables.

It is known that the polygalacturonic acid or demethoxylate pectin combines with calcium to produce calcium pectate. These compounds lend additional firmness to the tissues and the result is better retention of the original texture. While the presence of some salt in water improves the quality of canned fruits and vegetables, it has been found that an excess of same or even inclusion of other salt causes harmful effects.

Quality of fruits and vegetables canned in hard-water areas may be improved by the addition of chelating agents to the canning water. These compounds sequester the trace metals that catalyze oxidative breakdown of food and thus can improve flavor, color, and texture of foods. They also prevent formation of insoluble metal salts which cause turbidity and consequently quality deterioration. One

of the most commonly used chelating agents is ethylenediamine tetraacetic acid (EDTA). The other compounds which have been used as water-softeners are the polyphosphates, calcium phytate, theourea, and citric acid.

In the study described in this paper, 500 ppm of CaNa_2EDTA and sodium hexametaphosphate (Na-HMP) were used at different levels of water hardness for canning apricots, sweet cherries, and carrots to determine their effects on quality, color, titratable acidity, pH, firmness, volatile reducing substances, and organoleptic quality for an extended period of storage (6 months) at 70 and 100 F.

EXPERIMENTAL

CaNa_2EDTA , Na-HMP, anhydrous calcium chloride (CaCl_2), and

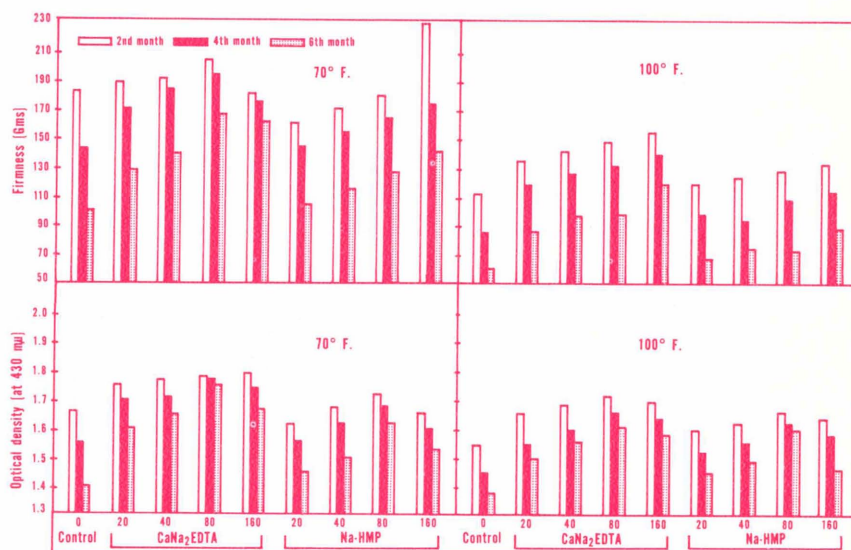


Figure 1. The effect of adding CaNa_2EDTA and Na-HMP to water of different hardness and the resultant firmness and color of processed carrots stored at 70 and 100 F.

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magnesium sulfate (MgSO_4) were obtained from Geigy Industrial Chemical, Ardsley, N.Y.; Calgon Corporation, Pittsburg, Pa.; and Baker Chemical Company, Phillipsburg, N.J., respectively.

The levels of water hardness were 0, 20, 40, 80, and 160 ppm of calcium. At each level of hardness, except 0 ppm, magnesium at 20 ppm also was included. The calculation was based upon the net fluid content per can.

Sweet cherries (cultivar:Van) and apricots (cultivar:Large Early Montgamet) were harvested at their optimal maturities for canning. Carrots (cultivar:Honey Sweet) were obtained from a local supermarket and sliced into 1/4- and 3/8-inch-thick pieces before canning.

The fruits of sweet cherries and apricots were canned with 40-percent sugar syrup containing 500 ppm of CaNa_2EDTA or Na-HMP while 800 ppm of CaNa_2EDTA or Na-HMP were used along with 2-percent sodium chloride brine for the carrots. The canned fruits and carrots were stored for 6 months at 70 and 100 F, respectively. At every 60-day interval, the samples were evaluated for the quality attributes.

QUALITY EVALUATION

The firmness in carrots and apricots was determined with a Chatillon gauge-r (a Magness pressure spring-type tester), 1/8-inch in diameter, while in the case of sweet cherries, the automatic sheer press machine NO. 3034 of Bridge Machinery Company was used. The color in sweet cherries (anthocyanins) and carrots (carotenoids) was determined colorimetrically. The color in apricots was measured by a Hunter color and color-difference meter. To determine titratable acidity, 25 grams of fruit were homogenized, diluted to 250 ml with distilled water, and titrated to pH 8.1 with 0.1 N sodium hydroxide. Readings for pH were made directly on blended and diluted (25 grams per 100 ml) samples. Volatile reducing

substances of the fruits were determined by the potassium permagnate oxidation method. The quality of the processed products was evaluated by a selected panel using a hedonic scale.

RESULTS

Carrots treated with CaNa_2EDTA lost firmness at a lower rate than those treated with Na-HMP. There was a consistent loss in firmness of the

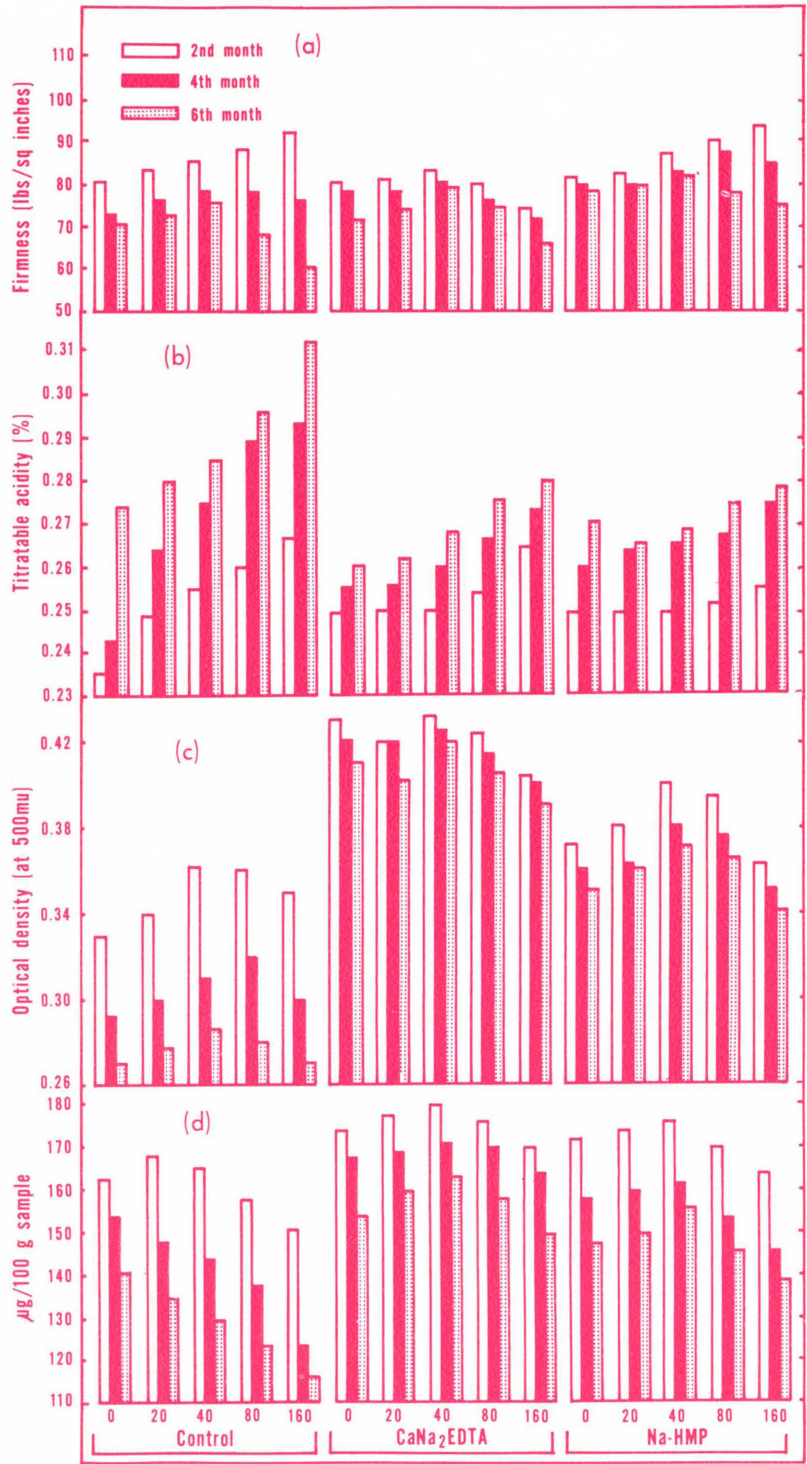


Figure 2. The effect of adding CaNa_2EDTA and Na-HMP to water of different hardness on the firmness (a), titratable acidity (b), color (c), and volatile reducing substances (d) of sweet cherries.

samples which were stored at 100 F, while, in the samples held at 70 F, the firmness decreased slowly up to the fourth month and thereafter rapidly (figure 1). A decrease in firmness was accompanied by a loss of color in samples at both 70 and 100 F. However, the samples treated with CaNa_2EDTA retained better color than Na-HMP (figure 1).

After 6 months of storage, sweet cherries and apricots retained less firmness than those canned with 40 ppm of water hardness (figures 2 and 3). The retention of firmness, volatile reducing substances, pH, and sensory acceptability was better in the samples treated with CaNa_2EDTA or Na-HMP than the controls (figure 2 and 3, and table 1).

DISCUSSION

Data from our study indicate that carrots, apricots, and sweet cherries canned with water containing 40 ppm of Ca with CaNa_2EDTA had better texture, color, and higher organoleptic acceptability scores. The higher concentrations of calcium, however, had adverse effects. This may have resulted because the demethoxylation of natural pectin produces pectic acid which may combine with calcium. This in turn may result in a toughening of the plant tissues. However, when an excess of calcium and magnesium is used for canning cherries and apricots, the calcium compounds are hydrolyzed and produce hydrogen ions in the solution. The hydrogen ions decrease pH, firmness, volatile reducing substances, color retention, and increase titratable acidity and tin corrosion.

A striking increase in the rate of deterioration of pigments along with decrease in pH is noticed in the samples canned with 80 and 160 ppm

of Ca. However, in the samples treated with sequestering agents, either CaNa_2EDTA or Na-HMP, the rate of deterioration of pigments (anthocyanins and carotenoids) during the 6-month storage period was not as pronounced as in the controls. Therefore, in addition to their water softening ability, EDTA and Na-HMP inhibit the degradation of pigments in canned sweet cherries and apricots.

Since the presence of iron or copper in canning water causes discoloration of the processed products by oxidation of carotenoids or anthocyanins, it has been suggested that EDTA or Na-HMP prevents discoloration by chelation with these metals. EDTA salts also synergize the anti-oxidant activity of ascorbate in fruits and vegetable products and prevent surface darkening.

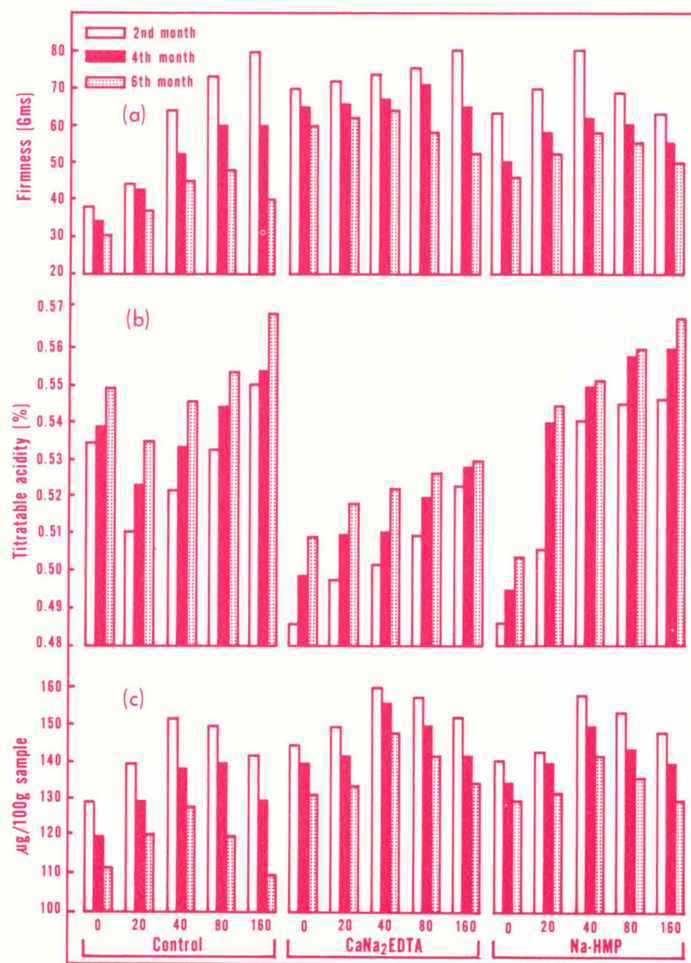


Figure 3. The effect of adding CaNa_2EDTA and Na-HMP to water of different hardness on the firmness (a), titratable acidity (b), and volatile reducing substances (c) of apricots.

Table 1. Effect of CaNa_2EDTA (500 ppm) and Na-HMP (500 ppm) at different water hardness on organoleptic quality evaluation of canned sweet cherries after a 6-month storage period at 70 F.

Quality	Control					CaNa_2EDTA (500 ppm)					Na-HMP (500 ppm)				
	0*	20*	40*	80*	160*	0*	20*	40*	80*	160*	0*	20*	40*	80*	160*
Texture	4.2	6.2	7.0	5.0	3.3	7.0	7.2	9.0	8.2	7.2	6.0	7.0	8.5	8.0	8.0
Flavor	4.0	4.5	5.1	5.3	3.5	7.2	8.0	8.5	8.0	6.8	6.5	6.5	8.0	8.0	7.5
Color	4.5	5.0	5.3	5.2	3.0	7.0	7.5	9.0	8.2	6.5	7.0	6.3	8.2	7.2	7.5

* Water hardness in ppm.

The future potential of shrubs on Utah ranges

GORDON A. VAN EPPS, A. PERRY PLUMMER, AND CYRUS M. McKELL

There are probably 40,000,000 acres of public land as well as thousands of acres of private land in Utah that are principally adapted for the grazing of livestock and big game. This is more than three-fourths of the land area in the state. Similar large percentages of other western states are primarily suited for this purpose. What are the possibilities of increasing the number of animals being grazed on these lands? At the present time, there are approximately 420,000 beef cattle and 1,058,000 sheep in Utah. It is estimated that there are 371,675 big game animals comprised of about 360,000 deer, 10,000 elk, and 1,000 antelope. In addition to these there probably are 200 bighorn sheep, 375 moose, and 100 buffalo in the state.

In addition to the livestock and big game, there are several kinds of native and introduced game birds in Utah. One of the most popular native birds is the sage grouse and increasingly popular exotics are the chukars. If the habitat of these birds were improved, no doubt, their number could be increased.

Could the number of livestock and game be substantially increased by planting palatable shrubs to supplement grass without being detrimental to the environment and requiring additional land? Game managers have suggested that by establishment of suitable shrubs, it would be possible

not only to increase the game we now have but to introduce other game animals into the state.

In the past, substantial increases in grazing have been made by seeding adapted grasses and legumes on marginal crop and range lands. Also, some improved pastures have been developed on irrigated land. A highly important question is "Why haven't shrubs been planted more widely for the improvement of range lands?" Considerable emphasis in the past has been given to planting grass and excellent results have been obtained. In contrast only minor efforts had been given to learning how to establish shrubs on rangelands,¹ until recently, when some research was undertaken by the Utah Division of Fish and Game and the Intermountain Forest and Range Experiment Station.² Extended plantings by these agencies as well as some larger plantings by the Forest Service and the Bureau of Land Management now show the excellent potential for seeding shrubs with grass.

¹ Plummer, A. Perry, Donald R. Christensen, and Stephen B. Monsen, 1968. Restoring big game range in Utah. Utah State Fish and Game publication number 68-3. 183 pp. illus.

² Plummer, A. Perry, Donald R. Christensen, and Kent R. Jorgensen, 1970. Highlights, results and accomplishments of game range restoration studies. Utah State Fish and Game publication number 70-3. 94 pp. illus.

Several palatable native shrubs are excellent forage and browse. The nutritive qualities, especially protein, in many shrubs remain particularly high throughout the year. Could the productivity of ranges be increased or periods of grazing be lengthened through successful shrub planting? Considering the ecology and the kinds of animals grazed, is it feasible to plant palatable shrubs with grasses? Many millions of acres in the west sustain only a negligible plant cover because they are too dry, saline, or possess other unfavorable soil and environmental conditions. In some cases the reason for a sparse plant cover may be simply a lack of understanding how to establish a plant cover. There may be a need for a shrub cover under which the grasses grow better in adverse habitats. We know that many of the best forage plants on desert ranges as well as those growing on the most severe sites are shrubs (figure 1).

On the basis of some accomplishments, we are confident that the above considerations with respect to the need and the possibility of establishing shrubs on ranges can be answered affirmatively. Many millions of acres in Utah, as well as in adjoining states can be made much more productive by planting shrubs in conjunction with grasses on the more unfavorable sites. In addition to improving grazing on both uplands and lowlands, a much

better plant cover can stabilize eroding soil. Shrubs can play an important function in doing this. While information regarding shrubs and other plants may not be available for accomplishing all the desired improvements, the basic groundwork has been laid for developing them through breeding, selection, and plant exploration. A combination of all of these

approaches likely will be required.

In contrast to large areas of depleted cover, millions of acres are presently supporting almost solid stands of low value brush and trees. Why not substantially replace these with productive and palatable kinds? Tremendous variations in indigenous populations of shrubs have been observed so we know that nature offers a

vast storehouse from which to develop better plants. Many existing stands of unpalatable big sagebrush (*Artemisia tridentata*) could be improved by planting palatable forms of this shrub or by other shrubs having high palatability as well as good tolerance to grazing. Observations show that there are differences in the palatability of ecotypes of big sagebrush and rabbitbrush (*Chrysothamnus nauseosus*) as well as within other shrub species. Differences in productivity are often immense between ecotypes of these same shrubs. For these reasons, we believe there are excellent possibilities for developing improved and adapted shrub strains through breeding.

Hybridization in nature has been observed between species and subspecies as well as between ecotypes within them (figure 2). That this can be done artificially and relatively easy has been confirmed by scientists working for the Intermountain Forest and Range Experiment Station and the Division of the Utah Fish and Game. Fourwing saltbush (*Atriplex canescens*) has been hybridized with shadscale (*A. confertifolia*) as well as by two forms of Gardner saltbush (*A. gardnerii*). Even black greasewood (*Sarcobatus vermiculatus*) was successfully hybridized with fourwing saltbrush. Antelope bitterbrush (*Purshia tridentata*) has been crossed with Stansbury cliffrose (*Cowania mexicana stansburiana*) and desert bitterbrush (*P. glandulosa*). Most of these crosses have been observed in nature. Natural hybrids of curleaf mahogany (*Cercocarpus ledifolius*), and birch leaf mahogany (*C. montanus*) are commonly seen. There is strong evidence that Stansbury cliffrose has hybridized with Apache plume (*Fallugia paradoxa*). Some putative natural hybrids of this unusual cross occur in northern Arizona on the Kaibab Forest. Common big sagebrush is normally regarded as low in palatability, but on extensive winter ranges, it is heavily grazed, and furnishes the main substance on which livestock and game thrive. Furthermore, wide differences have been ob-



Figure 1. Winterfat growing well in association with several grasses on a shallow soil in central Utah, formerly occupied by juniper and pinyon trees. Shrubs of fourwing saltbush are scattered through the area.



Figure 2. Hybridization of saltbushes. Shadscale saltbush (*Atriplex confertifolia*) on right, "Castle Valley" clover saltbush (*A. cuneata*) left, and hybrid in middle. Hybrid retains considerable spiny aspect of shadscale but retains leaves and greater succulence of "Castle Valley" clover.

served in the palatability of sagebrush forms within the various subspecies. In nature, subspecies of this sagebrush hybridize readily, and the hybrids produce good seed that result in immensely variable populations. Black sagebrush (*A. arbuscula nova*) and low sagebrush (*A. arbuscula arbuscula*) hybridize readily with big sagebrush. From what we have seen, artificial hybridization should not be difficult.

It is clear that new and better shrubs can be developed to serve a multiplicity of needs for livestock and game as well as the establishment of a stabilized cover on eroding soils. Some shrubs such as the saltbushes and rabbitbrush grow rapidly while others, such as the mahoganies, are much slower, but all serve worthwhile ends in the development of improved habitats.

A large number of shrubs have rated high in their success in one to several environmental areas. Ten shrub genera showing high promise for improvement of grazing as well as for stabilizing soil in their respective areas of adaptation are the saltbushes (*Atriplex*), sagebrush (*Artemisia*), rabbitbrush (*Chrysothamnus*), winterfat (*Eurotia*), bitterbrush (*Purshia*), wild cherry (*Prunus*), mahogany t (*Cercocarpus*), serviceberry (*Amelanchier*), buckbrush (*Ceanothus*), and oak brush (*Quercus*).

Since all evidence points to much better adaptation of shrubs through selection and breeding, it is important that we learn how to produce seed from them efficiently and economic-

ally. If we are to bring our range lands up to their potential production, we must learn to produce seeds of shrubs as is being done for a number of grasses. Some preliminary trials are underway by the Utah Agricultural Experiment Station at Nephi and Ephraim (figure 3). Some extended plantings of fourwing saltbush and antelope bitterbrush have been made by the Utah Division of Fish and Game. Along with this, purity and germination standards must be developed.

For the most part, seeds of shrubs are presently hand collected from wildland stands. Consequently, costs are unduly high and supplies are often extremely limited and sometimes of poor quality. Techniques of harvesting the seed with minimum damage is an important requirement. The growing of improved shrubs for seed production could be an important source of new income in many areas in Utah as well as elsewhere in the west.

To make such a program a reality, much more impetus must be given to developing adapted shrubs and seed sources for planting on vast areas. Better use of our wildlands must be obtained if we are to meet the expanding pressure of our developing and expanding society. Shrubs have too long been overlooked for their beneficial uses. We must now find ways to utilize their great potential for improved browse for livestock and game, as well as for watershed cover and extensive landscaping.

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LOW TEMPERATURE TOMATOES

(Continued from page 8)

and allow a machine harvest. In this way, growers could seed tomato plants directly in the row and be assured of a full crop before fall frosts.

The program aimed at developing varieties with the foregoing characteristics was started early in 1969. Two main parent varieties were used in the program, one was a small, early variety, Plant Introduction Number 341-988. It has the ability to germinate at 50 F whereas most varieties require a temperature of 60 F. The other parent was the most widely grown California mechanical harvest variety, 145-B-7879. It is a medium-sized variety that has the ability to remain in good condition on the vine after ripening, and to be handled roughly without serious bruising. It also is resistant to *Fusarium* and *Verticillium* wilts, two diseases which occur in Utah.

Our investigations have shown that the ability to germinate at low temperatures is inherited, and that a single recessive gene confers the low germinating ability. This knowledge enabled us to select low temperature germinating plants in the F₂ and then cross the earliest of them back to the larger mechanical harvest variety from California. During the winter of 1970-1971, the F₂ of the backcross was grown in the greenhouse; the best plants of the F₂ generation were selected, and their offspring will be field grown and tested in 1971. Present indications are that several of the selections will have the characteristics for which we are looking. If they do, there should be enough seed available for commercial planting in 1972.



Figure 3. Spaced plants of antelope bitterbrush being selected for seed production on the Nephi Field Station in central Utah.

Halogeton poisoning in sheep

Halogeton poisoning continues to plague livestockmen who graze sheep on the desert regions of the intermountain west.

Halogeton is an annual plant that grows in the colder arid and semi-arid areas. It grows in places where the soil has been disturbed or where the existing plant cover is inadequate or weakened by overgrazing. Therefore, the density of halogeton varies from an occasional plant on the better ranges to increasing amounts on ranges in poorer condition. Near pure stands can be found along roadways, abandoned fields, old bed grounds, water ponds, around ant hills, and in other areas where the soil has been disturbed.

The toxicity results from a chemical compound called oxalate. The amount varies from 10 to 30 percent of the dry weight of the whole plant.

Halogeton is grazed to some extent all the time by sheep using desert ranges. Under certain conditions, they are enticed to graze excessive amounts which then cause death.

An understanding of what happens to the oxalate when a sheep eats halogeton and the conditions that lead to them eating too much can help prevent poisoning.

When a sheep eats halogeton, the oxalate goes into the rumen, the first of the sheep's stomachs. Here the oxalate may: (1) be degraded to non-toxic materials by the rumen microorganisms, (2) combine with calcium to form insoluble calcium oxalate, or (3) be absorbed into the blood stream where it combines chemically with certain material such as calcium and certain enzymes. When excessive amounts are eaten and subsequently absorbed, death results.

Sheep must graze oxalate-produc-

LYNN F. JAMES

ing plants for a few days before the microorganisms become accustomed to this chemical and thus be able to degrade it. This would suggest that sheep should be introduced slowly to ranges where halogeton is consumed. The amount of halogeton required to kill a sheep that has been grazing halogeton is greater than one that has not.

There are a number of factors influencing livestock poisoning by halogeton. These are (1) how full the stomach or rumen is (or hunger) (2) toxicity of the plants, (3) amount of plant consumed and (4) rate of consumption, and (5) thirst. When the rumen is full, a sheep is much less likely to eat enough halogeton to have a toxic effect; and if they do, the oxalate is diluted, thus slowing the rate of absorption. The toxic dose is much less for a hungry sheep than it is for one that is not. It requires only about 60 percent of the amount required to kill a sheep that is full to kill a hungry one. A sheep can tolerate much greater amounts of halogeton when it is eaten slowly over a long period than when it is consumed rapidly.

Hunger and thirst can result at such times as when trucking, trailing, or when grazing on overgrazed ranges. Water intake is influenced by the amount of dry material an animal eats, temperature, and the amount of salt in the diet. As any of these increase, water intake must increase. Desert plants and especially halogeton are high in salts, therefore, causing increased thirst. When water is withheld, feed consumption necessarily decreases. As feed intake decreases, the

sheep becomes hungry and when water is supplied, the animal is ready to eat. Halogeton poisoning often occurs at times such as this because water is often supplied near dense stands of halogeton. When thirst is relieved, the sheep, being hungry, eat the forage most accessible. If this happens to be halogeton, death can result.

With the above information, a program can be devised that will decrease the possibility of halogeton poisoning in sheep. The main points at such a management program are discussed below:

TO MANAGE SHEEP ON HALOGETON INFESTED RANGES:

1. Sheep should be introduced slowly onto ranges infested with halogeton.
2. Sheep should not be allowed to become hungry prior to moving into areas having heavy stands of halogeton. This can be prevented by providing adequate forage and water.
3. Supplementary feed should be provided if native forage is not available in adequate amounts. Such should include a mineral supplement as dicalcium phosphate.
4. A grazing plan should be made out so as to avoid grazing sheep on heavy stands of halogeton, such as old bed grounds, around watering ponds, and other denuded areas. If sheep are to be grazed into these areas, precautions should be taken.
5. Sheep should be managed to provide a continuous smorgasbord of forage species, so to speak.

LYNN F. JAMES is a Federal Collaborator for the Agricultural Research Service.

Goatsrue, a potential forage crop, turned out to be a weed

D. C. TINGEY

Goatsrue (*Galega officinalis* L.) is a weed in localized areas of Cache Valley, Utah. Data are not available to indicate the acreage infested. Goatsrue is found mostly in irrigated areas under the Logan-Richmond Canal. It is most likely to be found in areas where the soil is moist throughout the growing season. It is prevalent along water ways, in irrigated or normally wet pastures and waste areas. There is little goatsrue south of Logan, and this weed has not been reported as being a problem in any other part of the state. Its distribution nationally is not known.

Goatsrue is a deep rooted, long-lived perennial which propagates by seeds only. It is a member of the legume family and its growth habit is similar to that of alfalfa (figure 1). Both goatsrue and alfalfa have a central tap root, with smaller branching roots. New growth starts from crown buds, as in alfalfa. It is not known if

goatsrue, unlike alfalfa, can develop adventitious buds along the central tap root from which new shoots originate. The plants produce many branches and under favorable conditions may grow 5 or 6 feet tall. The leaves are odd-pinnate with 5 to 8 pairs of leaflets. The flowers are blue or white in terminal or axillary racemes similar to alfalfa. Instead of the pods being curled like those of alfalfa, they are narrow, straight, round in cross section, and about 1-inch long. The seeds resemble those of alfalfa, but are much larger.

Goatsrue contains a poisonous alkaloid known as galegin. The plants have a bitter taste and are unpalatable to cattle and horses. The seeds and mature plants are reported to contain enough galegin to be unsafe as a feed for livestock. Young leafy plants, prior to bloom, have been fed without difficulty, however.

The poisonous property of goatsrue is interesting. Even though it is common in pastures where heavy grazing is practiced, there have been few reports of livestock poisoning. The reason for this probably because the plants are low in palatability and eaten very little if at all by cattle and horses (figure 2). Some cases of sheep poisoning have been reported. Reports from Italy indicate in some tests the galegin content of goatsrue was as high as .5 percent.

During the 1940s and even up to 1959, there were reports from Italy where attempts have been made to breed and develop strains of goatsrue low in galegin for livestock forage. They report goatsrue yields as high as any other forage in their area. Because of its high yield, it could serve as a good green manure crop, but a seed supply is not presently available.

AREA HISTORY

Goatsrue is a native of Europe and Western Asia. Before the turn of the century and even more recently, goatsrue was considered to be a plant of considerable promise as a forage and green manure crop in certain European Countries. Goatsrue was among the earliest forage crops tested at the Utah Agricultural Experiment Station. It was mentioned in the fourth annual (1893) report. Director J. W. Sanborn reported that Station officials began a 3-year series of experiments with forage crops that would be best suited for this arid region, and could be grown without irrigation. The plots were located on the bench lands



Figure 1. Close up view of goatsrue in a pasture.

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Figure 2. Goatsrue in a heavily grazed pasture. It is not eaten by the livestock so it thrives under these conditions.

east of the few buildings constructed by the college at that time.

In addition to goatsrue, other forages tested were alfalfa, sanfoin, alsike clover, sweet clover, red clover, and grasses such as orchardgrass, tall fescue, timothy, Reed Canary, Hungarian brome or smooth brome, and a number of others.

In these tests, Goatsrue yielded only about one-half that of alfalfa. Alfalfa yielded over 5 tons per acre. Considering the fact that the forages were not irrigated, yields were exceptionally high. Furthermore, the feed value in alfalfa was much higher than in goatsrue. The crude proteins in goatsrue were only about one-half as high as in alfalfa.

Goatsrue is not very palatable to cattle and horses. Its low yield and quality and low palatability make it easy to understand why it turned out to be a weed in this area and not a useful forage crop such as alfalfa.

A WEED BY EARLY 1940s

From these early plantings of goatsrue in 1891-1893, there is no further record of this species in this area until

1909, a period of 18 years. On August 4, 1909, Professor Charles Piper Smith of the Botany Department at the College, collected and mounted a specimen of goatsrue which is still in the herbarium of the Utah State University. Prof. Smith reported that he made the collection along the highway between the College and the Greenville Experimental Farm.

The writer's first experience with goatsrue was in the late 1920s. A specimen of goatsrue was collected on the College-Greenville road along the ditch west of the County Poor Farm, in the vicinity of the present Van Noy apartments. The same general area where Professor Smith made his collection in 1909.

Some local farmers have thought that the college officials were responsible for bringing goatsrue into this area and was the source of the present infestation in Cache County. Because of this, goatsrue became known as "professor" weed. Many farmers refer to it by this name. Of course, no one knows, and probably never will know, how and when the present infestation of goatsrue got started in this area.

It is of interest, however, to ex-

amine the data available. From the time goatsrue was first brought in to be tested as a forage crop in 1891 up to 1925, a period of 34 years, it had not been observed as a weed in the area where it was first planted. In addition an irrigated pasture was established either on the same area where goatsrue was planted or on an immediately adjacent area. Goatsrue is most likely to invade cropland by establishing in irrigated pastures.

The collection of goatsrue made by Professor Smith in 1909 and the one made by me in the late 1920s were about 1 mile from where the original planting of goatsrue was made in 1891.

However, it should be noted that the goatsrue was grown as a forage and was mowed as one would now alfalfa. This would prevent seed production and limit the spread of goatsrue to other areas. In addition, two intensive weed surveys in northern Utah failed to list goatsrue.

The information available would indicate that the planting of the goatsrue made by the college officials in 1891 for testing for forage purposes was not the original source of the present infestation in Cache Valley.

New weed species are constantly finding their way into Utah, and finding environments where they can become troublesome. Goatsrue is no exception. Other weeds that have become problems during the past four decades are: (1924-1967) woad (*Isatis tinctoria*), Romeria poppy (*Roemeria refracta*), biscuitroot (*Lomatium leptocarpum*), pheasant-eye (*Adonis annua*), snow weed (*Veronica campylopoda*), puncture vine (*Tribulus terrestris*), bur buttercup (*Ranunculus testiculatus*), squarrose knapweed (*Centaurea squarrosa*), sweet clover (*Melilotus alba* or *M. officinalis*), kochia (*Kochia scoparia*), bassia (*Bassia hyssopifolia*), wild mustard (*Brassica* sp.), tansy mustard (*Descurainia sophia*), shepherd's purse (*Capsella bursa-pastoris*), and quack-grass (*Agropyron repens*) to mention only a few.

HERBICIDES CONTROL

Two experiments were conducted to determine the effectiveness of herbicides in the control of goatsrue. In one experiment, there were 12 formulations of dichlorophenoxyacetic acid (2,4,-D) used. All materials were used at rates of 2, 4, and 6 pounds per acre. One application was made at the bloom stage of growth. Plots were 1 square rod in area and the treatments were not replicated. On May 3 and August 5 of the year following the application of the herbicides an estimate of the density of goatsrue was made on each plot.

In the second experiment, seven herbicides were used. Five of these were 2,4-D formulations, applied at rates of 2, 4, and 6 pounds per acre and at four stages of growth of the goatsrue. Two additional herbicides were applied at two rates and at two stages of growth. Each treatment was replicated three times in a randomized block design.

The first application, made in the second experiment, was at the early seed stage of growth of the goatsrue. The other three treatments were made the following year; one each at pre-bud, bud, and bloom. Plots for all treatments were randomized in each replicated block. In this second experiment, the plots were $\frac{1}{2}$ rod square. The density of goatsrue before treating was uniform and averaged 80 percent of the soil surface covered. This second experiment was located on the farm adjacent to the farm on which the first test was conducted. The land on which the second experiment was located was poorly drained and the surface soil remained moist throughout the growing season. Except for the sodium chlorate and polyborate, which were applied in the dry granular form, the others were applied in water at the rate of 40 gallons per acre.

TREATMENT RESULTS

Percent density of goatsrue on two dates the year following the application of various formulations of 2,4-D applied at three rates, appear in Table

1. The percentages include both old plants and seedlings.

Using the herbicides x rate interaction as experimental error, there

was a significant difference in rates and herbicides. While there was a large number of exceptions, the higher rates were generally more effective.

Table 1. Percent density of goatsrue on May 3 and August 5 of the year following one application of 2,4-D herbicides at the bloom stage of growth.

2,4-D formulations	Goatsrue density							
	May 3				August 5			
	2 lb/A	4 lb/A	6 lb/A	Avg	2 lb/A	4 lb/A	6 lb/A	Avg
Acid	25	90	40	52	45	88	60	64
Ammonium	25	5	5	12	45	20	40	35
Ammonium	60	100	50	70	97	90	75	87
Sodium	40	20	50	37	50	55	50	52
Butyl ester	80	60	40	60	95	85	90	90
Ethyl ester	40	20	15	25	45	55	60	53
Methylester	70	10	10	30	80	30	40	50
Alkanolamine	75	5	35	38	98	45	55	66
Triethanolamine	50	65	5	40	65	95	40	67
Triethanolamine	60	20	----	40	80	40	----	60
Triethanolamine	75	70	5	50	98	90	45	78
Triethanolamine	80	70	50	67	95	85	75	85
Average	57	45	28	43	95	85	75	65

Table 2. Percent density of goatsrue (old plants) the following year after being treated with one application of various herbicides applied at different rates and stages of growth.

Herbicide	lbs/A	Stages of growth				
		Early seed 9/18	Pre-bud 5/18	Bud 6/19	Bloom 7/12	Final avg
2,4-D amine	2	28	30	29	10	24
	4	17	35	21	9	20
	6	3	39	17	1	15
	Avg	16	35	22	7	20
2,4-D ethylester	2	22	24	27	45	29
	4	7	32	32	15	21
	6	9	29	26	9	18
	Avg	13	28	28	23	23
2,4-D ethylester plus 10 gal. oil	2	7	47	43	49	36
	4	10	25	40	17	23
	6	12	18	38	19	22
	Avg	10	30	40	28	27
2,4-D butoxyethanol ester	2	13	58	23	33	32
	4	27	28	38	10	26
	6	5	31	37	10	21
	Avg	15	39	33	18	26
2,4,5-T propylene glycol butyl ether ester	2	1	37	25	3	16
	4	0	17	11	4	8
	6	0	18	7	0	6
	Avg	0	24	14	2	10
Sodium chlorate	160	40	33	----	----	36
	320	32	8	----	----	20
	Avg	36	20	----	----	28
Polyborate	160	40	72	----	----	56
	320	23	35	----	----	29
	Avg	31	53	----	----	42

Among the herbicides, the greater differences were between those within the same type of 2,4-D rather than between the types. An example of this is between the two ammonium forms. Apparently the formulation is more important than the type of 2,4-D on the control of this weed. Nearly all plots had a higher density on August 5 than on May 3. This increase could be caused by any one or a combination of conditions: (1) an actual increase in density; (2) variation by the estimator; and/or (3) an increase in plant size could have influenced the estimation. A few treatments showed satisfactory control on May 3, but these had mostly disappeared by August 5. Recovery of some old plants and new seedlings likely accounted for much of the increase. Goatsrue seedlings will present a problem in any method of control, but they are not any more difficult to control than other weed seedlings.

Density estimates of goatsrue in the second experiment appear in tables 2 and 3. Table 2 includes the density of goatsrue the first year following one application of herbicides and table 3 includes the density of the second year. The density in table 2 includes old plants only and table 3 includes old plants and seedlings.

Data in table 2 show some marked differences in the treatments of the first year following the application. Better control was obtained at the early seed and bloom stages rather than at the pre-bud or bud stages. In addition, 2, 4, 5-T was more effective than the other herbicides. It is also about twice as expensive. Higher rates, on the average, gave slightly better control, but not enough to justify the use of more than 2 pounds per acre.

The higher rates of sodium chlorate and polyborate gave about the same control as the 4-pound rate of 2, 4-D. Cost of the sodium chlorate and polyborate at these rates is several times higher than for the 2 pounds of 2,4-D.

By the second year, due mostly to seedlings, the density was nearly back to where it was at the beginning, except where high rates of sodium chlor-

ate and polyborate were applied. Furthermore, the treatment effects which showed up the first year had mostly disappeared by the second year (table 3).

GOATSRUE CONTROL

There are various methods of controlling goatsrue. While this article deals with the use of certain herbicides as related to goatsrue control, it is appropriate to point out some of the other methods. Among these are cropping, cultivation, and crop rotation. Some of the more recently introduced herbicides would probably be more effective than the ones listed here, but they have not been cleared for use in a cropping program where the crops are used for either livestock feed or human food.

Goatsrue is not likely to become a serious weed on tillable land where good farming methods are practiced and various crops grown in rotation.

Pastures infested with goatsrue ought to be plowed, if possible, and

put into crops for a few years. Most any cultivated crop would be suitable, such as corn, sugar beets, or potatoes. Grain could also be grown and 2,4-D used to control the goatsrue seedlings.

I have never observed goatsrue as being a problem on tillable land. Goatsrue could be controlled in pastures by mowing several times during the season. Divide the pasture and practice rotation grazing. Then mow the grazed area after each grazing period. This will keep goatsrue under control and prevent spreading. This treatment would not likely kill the old plants, but it would keep them from producing seed and prevent further spreading. Spot spraying with 2,4-D will also help.

Goatsrue could cause some difficulty on tillable land where it is permitted to produce seed in pastures and then the land is planted to another crop. Since goatsrue is so unpalatable to livestock, it will probably produce seed wherever it is growing if it is not kept mowed.

Table 3. Percent density of goatsrue including old plants and seedlings the second year following one application of various herbicides applied at different rates and stages of growth.

Herbicide	lbs/A	Stage of growth				
		Early seed 9/18	Pre-bud	Bud	Bloom	Final avg
2,4-D amine	2	55	67	71	65	64
	4	77	86	26	73	65
	6	65	64	88	67	71
	Avg	66	72	62	68	67
2,4-D ethylester	2	57	54	66	82	65
	4	50	66	69	68	63
	6	43	57	70	50	55
	Avg	50	59	68	67	61
2,4-D ethylester plus 10 gal. of oil	2	61	66	55	62	61
	4	53	58	65	55	58
	6	72	100	90	42	76
	Avg	62	75	70	53	65
2,4-D lowvolatile ester (butoxy ethanol ester)	2	60	76	65	87	72
	4	41	60	65	62	57
	6	47	91	59	83	70
	Avg	49	76	63	77	66
2,4,5-T propylene glycol butyl ether ester	2	65	73	68	47	63
	4	62	52	45	58	54
	6	33	82	71	42	57
	Avg	53	69	61	49	58
Sodium chlorate	160	58	82	----	----	70
	320	38	28	----	----	33
	Avg	48	55	----	----	51
Polyborate	160	40	87	----	----	63
	320	7	58	----	----	32
	Avg	23	72	----	----	47

Pinyon-Juniper Chainings— and Deer?

TED L. TERREL and J. JUAN SPILLET

Personnel from the Utah Cooperative Wildlife Research Unit at Utah State University are attempting to find answers to the perplexing question—"How compatible are mule deer and converted pinyon-juniper (P-J) ranges in Utah?" Studies sponsored by the Bureau of Sport Fisheries and Wildlife, the Bureau of Land Management, the Utah Division of Fish and Game, and the Wildlife Resources Department at Utah State University are in the second year. Primary objectives of the studies being conducted on the Mayfield chainings south of Manti are: (1) to evaluate the seasonal and daily use by deer of adjoining converted and natural P-J winter range areas, and (2) to determine the major factors influencing such use patterns.

The P-J woodland type, which covers nearly 76 million acres in western North America, is the most extensive woodland type in the world. Approximately 25 percent of Utah is covered by P-J, most of which is important deer winter range.¹ About 3 million acres of P-J in over 1,200 projects throughout the West had been converted to grasslands by 1964.² Since 1950, many thousands of acres of P-J in Utah have been converted, with public agency plans calling for extensive projects in the near future.

CHAINING

"Chaining" is the most common method used to convert P-J wood-

lands into grass land or grass-shrub communities. In this process, ship anchor chains, with links weighing up to 90 pounds each, are pulled between two large crawler tractors of at least 45 horsepower. Five to 15 acres per hour can be chained. These heavy links effectively uproot the trees and prepare a seedbed. A mixture of grass, forbs, and browse seed is then aerially seeded and the seed covered by dragging the chain over the area a second time. Seeds frequently used include those of grasses such as crested wheat, intermediate wheat, Russian wild rye, and smoothbrome; forbs such as yellow sweet clover and nomad, Ladok and Rambler alfalfas; and shrubs such as fourwing saltbrush, curleaf mahogany, antelope bitterbrush and rubber rabbitbrush. Chain links 70 pounds or heavier effectively kill the supple P-J seedlings, but also do extensive damage to the shrub under-

story. Chaining and seeding usually result in a great increase in grass production, with less pronounced gains in forb and browse growth. Of course, on double chained ranges, juniper browse is decreased. In Montana, one researcher³ found 13 percent juniper by volume in winter deer rumen samples. Knowledge of the importance of juniper in the winter diet of Utah deer is virtually unknown, a vital "missing link" which may be answered by the present studies.

DEER OBSERVATIONS

Observations of feeding deer systematically recorded during January and February, 1971, on the Mayfield chainings and adjacent natural P-J

³ Mackie, R. J. 1970. Range ecology and relations of mule deer, elk, and cattle in the Missouri River Breaks, Montana. Wildlife Monograph No. 20. 79 pp.

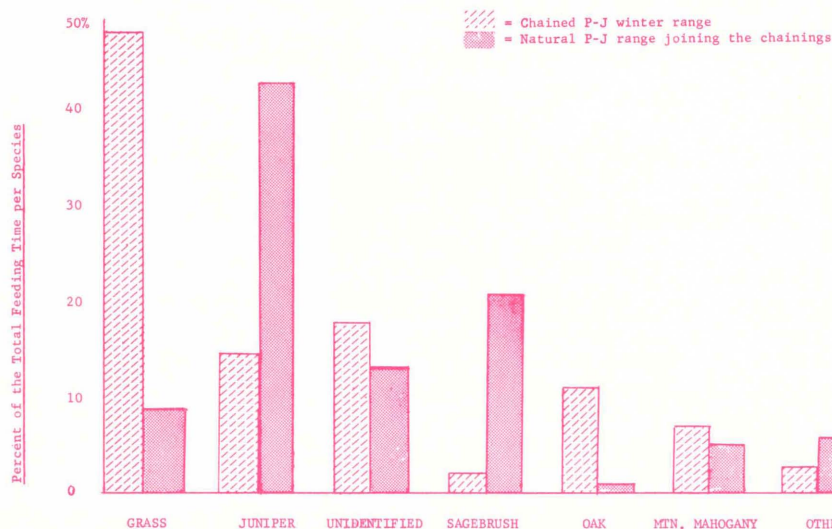


Figure 1. A summary of the feeding habits of 218 deer (86 in natural P-J and 132 on chained P-J areas) near Mayfield, Utah during January and February, 1971.

¹ Woodbury, A. M. 1947. Distribution of pigmy conifer in Utah and northeastern Arizona. Ecology 28:113-126.

² Box, T. W., G. M. Van Dyne, and N. E. West. 1966. Syllabus on range resources of North America, part iv. Pinyon-Juniper ranges. Utah State University, Logan. 8 pp. mimeo.

ranges are presented in Figure 1. Deer utilizing the chained P-J areas during this period fed primarily on grasses. However, it should be noted that unreasonably warm weather from mid-January to mid-February caused the grasses to sprout on the area. Deer on the natural P-J areas fed primarily on juniper and sagebrush. Continued observations this spring and next winter should contribute significantly to our understanding of the value of P-J chainings in a deer's life.

Most P-J conversion projects, on both private and public lands, are undertaken primarily to produce additional forage for livestock and for watershed protection. However, some P-J conversion projects have been planned for the benefit of wildlife, particularly deer. For example, the 5,000-acre chaining on Deer Herd Unit No. 40 near Mayfield, in San Pete County, was a cooperative program undertaken by the Bureau of Land Management and the Utah Division of Fish and Game (figure 2).

The primary objective of the project was to provide additional winter forage for deer. The ecological effects of such conversion on deer are largely unknown, although the practice is generally thought to be beneficial. However, limited studies in Arizona and New Mexico have yielded some conflicting data. The extent to which those studies apply to Utah conditions needs to be evaluated. Sound biological guidelines for chaining design and composition must be formulated before resource management goals can be realized. Such guidelines should be built around knowledge of actual deer use patterns on existing conversion projects.

Prior research on this problem has been restricted to indirect methods, such as pellet group counts and forage surveys. No one had, until initiation of this study, actually observed deer for any extended period of time on the converted P-J woodlands. Thus, considerable emphasis on this Utah research is being placed in this area. Observations of deer on the chainings



Figure 2. This pinyon-juniper range near Mayfield, Utah was double-chained and aerially seeded with grass, forbs, and browse seeds.



Figure 3. Movements of deer on natural and chained pinyon-juniper ranges are being monitored by the use of radio transmitters and blinking neon lights, which are attached to collars placed on deer during the fall.



Figure 4. Locations of deer marked with numbered ear ribbons are recorded to determine daily and seasonal movements in relation to natural and converted pinyon-juniper ranges.

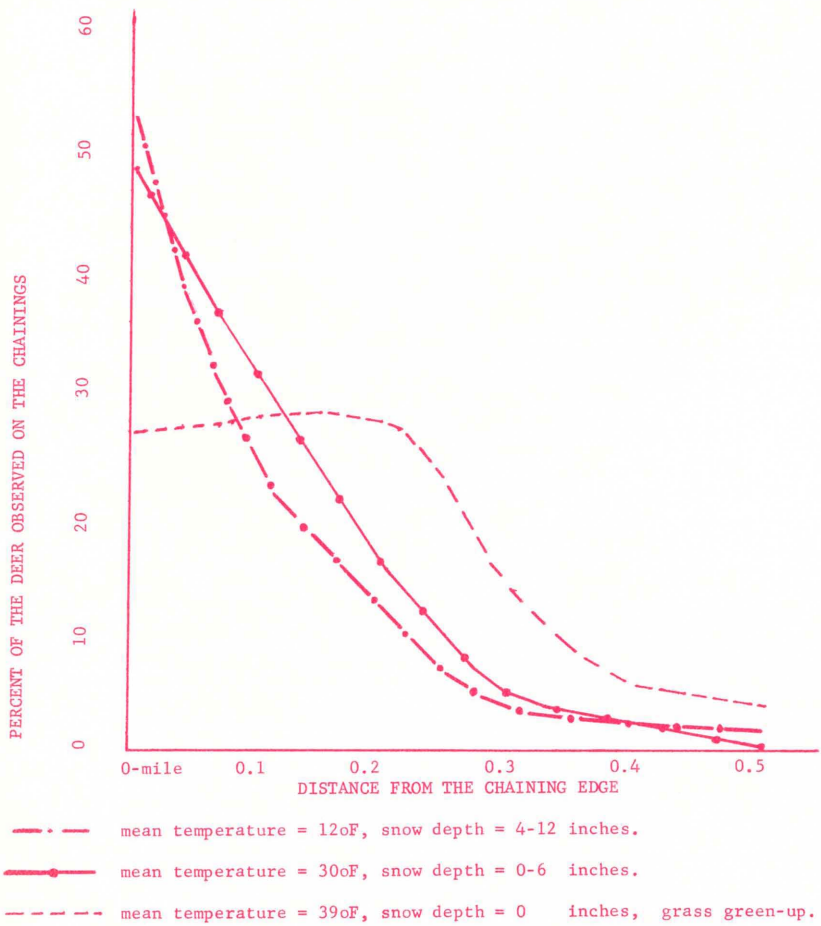


Figure 5. Effects of temperatures, snow depth, and distance from cover on deer use of pinyon-juniper chainings (Mayfield, Utah, October 1970-February 1971).

will be continued during this and next winter and spring to obtain a more complete picture of deer use.

A part of these observations involves the location and tracking of deer by radio transmitters and neon lights. These are attached to leather collars placed on deer trapped at the beginning of each winter. The radios and lights have been used separately and together. Best results have been obtained when the radio transmitter and neon light were placed on the same collar (figure 3). At night, the deer's general location can be "fixed" by using a radio receiver. Precise movements then are obtained by watching the small, flashing light mounted on top of the deer's collar. The light is visible for a distance of about 300 yards and has a battery life expectancy of 10 months. The radio signal can be received up to a distance of about 3 miles on flat ground, and the radio battery pack has a life expectancy of 2 years. Movements of deer marked with numbered eartags also are recorded (figure 4).

THE DATA

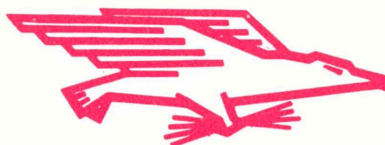
Valuable movement data pertaining to vegetation types, weather factors, and chaining size also are being systematically recorded and punched on IBM cards for computer analyses. Data on the effects of temperature, snow depth and distance from cover of deer use of converted P-J areas are presented in Figure 5. These indicate that with colder temperatures and deeper snows deer remain closer to natural P-J areas and use only the edges of chained areas. Also, deer use chained areas primarily under relatively mild weather conditions during grass green-up.

Some specific questions which hopefully will be answered by these studies are: (1) during which months do deer use the chained P-J areas most? (2) What particular aspects of the chainings are most valuable or detrimental to deer? (3) How deep do deer penetrate into the chainings under various weather and cover conditions? and (4) Over how large an

(Continued on page 32)

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THE CASE OF . . .

THE WANDERING MOOSE

It was Wednesday, October 28, 1970. Barry Barnes, a native of Canada who had recently come to Utah State University as a graduate student in Wildlife Resources, was driving up Blacksmith Fork Canyon. With dusk approaching and being unfamiliar with the country, Barry stopped the car on a small rise to check his map to determine his location. He was about 1 mile from the Elk Valley Guard Station.

He was about to start the car when

a large animal came into view on the road ahead. A quick look through his binoculars proved it to be a cow moose. He had heard there were a few moose in the Cache National Forest, but that they were so sparse that they were rarely seen. Although light conditions were not good, he determined to try to take some photographs of the animal. While getting his camera and lenses from the back seat, two more moose appeared along the road. These were both calves, ap-



Figure 1. Moose are seldom seen in the Cache Valley area, but last fall, some strangers wandered in.

parently the twins of the cow in front of them.

The moose continued down the road towards the parked car, paying no apparent attention to it. The cow then moved off the road and started to walk past the car, but then turned and approached the car until she was within 8 feet of it. It was at this time that Barry noticed she had a small yellow tag in the right ear and he also took a photograph of her.

The cow circled the car and the calves moved off the road and followed her along the sidehill, still paralleling the road.

As the three animals moved off, Parry was again about to start the car when a second cow moose walked across the road in front of him. Then to his surprise he saw yet another moose, a young bull, further ahead in the valley. These also walked past the parked car and followed the cow and calves, which were now behind him.

Subsequently, Barry reported the incidence and showed the photograph of the marked moose to Dr. Juan Spillett, Assistant Leader of the Utah Cooperative Wildlife Research Unit at Utah State University. He, in turn, reported the sighting to Jack Rensel, Northern Regional Supervisor for the Utah Division of Fish and Game. A check of the Fish and Game tagging records indicated that no moose had been marked with yellow tags in Utah. Therefore, the fish and game organizations in adjoining states of Wyoming and Idaho were contacted. Wyoming, likewise, had never marked moose with yellow tags. However, Idaho reported marking a number of moose with yellow tags on a project conducted between St. Anthony and West Yellowstone—a distance of over 160 air miles from Elk Valley where the animal was sighted.

P. J. DEER STUDY

(Continued from page 31)

area does a typical deer roam? Concurrent studies of deer use on natural P-J ranges adjacent to the chained areas should provide information upon which to evaluate the worth of P-J chainings as a deer management tool, and provide effective guidelines for future P-J conversion projects.